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(54) **Methods and apparatus for dynamically refining and deodorizing fats and oils.**

(57) A method and apparatus for distilling, especially vacuum refining and deodorizing edible oils and fats utilizing sheets of oil driven downwardly in a distiller with a vacuum source at its top Fig 3,4. A nozzle includes pressure equalization chambers, cantilever adjustment screws, and a central drag sheet to produce longer lasting and more uniform thin oil sheets to be driven in the distiller Fig. 5 and 11. A continuous process deaerates, dehydrates, degums Fig. 1 and 10, bleaches Fig. 1 and 12, refines Fig. 1 and 14, removes tocopherol Fig. 1 and 16, deodorizes Fig. 1 and 18, and strips peroxides and hydroperoxides Fig. 1 and 20, from raw oil in a series of isother mal stages utilizing driven sheet distillers. No stripping steam is used except in the stage which strips peroxides and hydro peroxides. The method produces valuable, pure products such as tocopherol and fractionated fatty acids. It is especially effi cient in heat exchange and low in waste and pollution producing products. A steam sparging nozzle for distributing steam in the stripping of peroxides and hydroperoxides includes a plurality of small tubes with openings which restrict steam flow so as to pro duce a uniform distribution of optimum size steam bubbles in the steam stripping column of oil Fig 12 and 13. A microwave excitation device radiates the oil immediately prior to forming the driven sheets to excite the more volatile components of the oil for distilling.

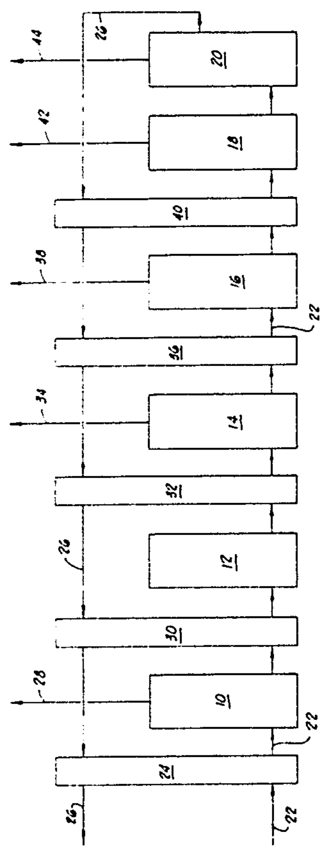

FIG. 1

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METHODS AND APPARATUS FOR DYNAMICALLY REFINING AND DEODORIZING FATS AND OILS

This invention relates to methods and apparatus for refining and deodorizing edible oils and fats and particularly to methods and apparatus for continuous vacuum refining and deodorizing of fats and oils.

In the process of refining either vegetable or animal fats and oils to prepare foods such as margarine and cooking oils, several processes are presently available. Generally, these processes utilize vacuum distillation to remove odoriferous substances such as free fatty acids from the oils and fats comprising mainly triglycerides. By this means, the oils and fats are made more palatable and their odors and tastes are improved.

While the odoriferous and taste giving materials are more volatile than the oils in which they are found, the oils and fats may not be subjected to relatively high temperatures since undesirable polymerization or production of additional fatty acids, alcohols, aldehydes, etc., from the fats and oils occur at higher temperatures. Accordingly, the preferred method of deodorizing fats and oils has been by means of a vacuum distillation allowing a lower temperature removal of these more volatile odoriferous substances. Most of these vacuum processes use a stripping agent such as steam to increase the surface area of liquid oil and fat, to provide a carrying medium for removal of the volatile substances and to react with and strip certain undesirable components. In vacuum steam stripping, the oils are contacted by steam percolating upwardly in columns or trays of oil at elevated temperatures and subatmospheric pressures.

Many prior art processes of deodorisation are discontinuous. The first step is the removal of water by soluble phosphatides, or more particularly, lecithins by degumming. Then, as the stability of the oil has been protected by the presence of the lecithins, the oil should be immediately deaerated and dehydrated through contact equipment operating at approximately 150°F to 175°F at reduced pressures.

Another step is bleaching, generally by the use of clays. Following these steps, the oil is refined and deodorised. It may contair., at this point, approximately 0.5% removable hydrocarbons with the balance being pure triglycerides. This 0.5% will contain about 85% free fatty acids and 15% tocopherol.

Two methods of refining are commonly used: caustic and steam. Caustic refining reacts the free fatty acids with caustic, saponifying the free fatty acid for removal. Steam refining recognises that most of the free fatty acids are subject to normal distillation and the method uses steam to spring and carry the distillates from the oil. Because of temperature constraints the latter method must be vacuum stripping and distillation.

Refining is generally a batch or semi-continuous process. The prior art has attempted to decrease the absolute pressure within the column in order to reduce the residence of the oil in the columns. Large amounts of energy are expended to accomplish the low pressure in order to reduce the residence and in order to make the volatile materials spring from the oil more quickly.

Present practice also overheats the oil all too frequently. Exceedingly high skin temperatures of the oil are created prior to the oil entering the columns in order to hurry the deodorisation to completion. It is well recognised that the longer the oil is subjected to higher temperatures, the more the oil breaks down to produce additional odoriferous materials which must also be removed from the oil. Of course, greater energy use to obtain higher vacuum, higher temperatures or shorter residence reduces the profitability of the process. If longer residence times are permitted, the increase in labour and decrease in availability of the equipment also reduces profitability.

With the prior art more and more horsepower has been utilised to increase the vacuum within the steam stripping chambers. As the current practice is not truly continuous, true product to product heat transfer cannot approach its ultimate efficiency as heat transfer is a function of time. Eductor steam has the disadvantage of not yielding its full energy into the production of the low pressure as all of its energy cannot be used in producing dynamic work upon the vapours to be removed. In other words, the eductor steam cannot expend its enthalpy energy upon the system.

For deodorisation, the quantity of eductor steam plus the stripping steam may equal the mass of the oil being deodorised. Since all the vapours are co-mingled with the steam flow, the total heat lost over head from the liquid oil is extravagant. Likewise, the mixture of hydrocarbon vapour and water vapour present a separation problem with a great deal of the hydrocarbon, when condensed, being sent to local sanitary facilities as this effluent is not acceptable for stream discharge. The BOD of the hydrocarbon water mixture is extremely high with most municipalities making surcharges. Desirable materials are discarded with the eductor and stripping steam which could be marketable if they were to remain uncontaminated. For example, tocopherol is frequency discarded along with fatty acids and water.

According to the present invention, there is provided a method of distilling a distillation product from raw edible oil characterised by the steps of forming a sheet of liquid edible oil having a relatively narrow thickness and a relatively large surface area; and moving said sheet of liquid edible oil in a distillation column at distillation temperature and pressure such that a distillation vapor product is formed therefrom and such that the surface of said sheet of oil moves rapidly with respect to vapor in said distillation column to promote distillation.

The invention also provides a distillation column nozzle for use in supplying a sheet of liquid in a distillation column and characterised by a central liquid inlet on one side, an elongated liquid outlet on the opposite side defined by first and second lips, a pressure equalisation means for communicating said inlet and said outlet and equalising liquid pressure longitudinally across said outlet; said pressure equalisation means comprising a plurality of longitudinal chambers connected by respective slots, respectively; said central liquid inlet being disposed for conveying liquid to a central portion of a first said longitudinal chamber; a first said slot connecting first and second said chambers having a relatively narrow central portion tapering to relatively wide end portions for longitudinal liquid pressure equalization; said elongated liquid outlet being disposed for receiving liquid from a final said chamber.

The invention provides an improved method and apparatus for deodorising fats and oils in an efficient continuous manner, preferably concurrently fractionating the distilled vapours into desirable by-products, without overheating or damaging the oil.

A vacuum producing device may be provided at the top of the chamber, preferably a liquid ring vacuum pump, so that vacuum is applied to a greater surface of oil in a manner which more efficiently springs the distillation vapours from the oil. The oil can be supplied to the chamber at a temperature appropriate for distillation at the pressure of the chamber. Preferably, the chamber includes a means for heating the oil to precisely the proper distillation temperature.

A plurality of such chamber nozzles to produce and properly form the driven sheets can be disposed at the top of the distillation chamber. Each nozzle is preferably configured so as to drive the thin sheets of oil downwardly at a high velocity while the sheet maintains its integrity for as far down in the column as possible.

The pressure equalisation means of the nozzle preferably comprises first, second, third and fourth nozzle chambers connected by first, second and third longitudinal slots, respectively. The inlet of the nozzle is connected to a central portion of the first nozzle chamber.

A central drag plate can be provided through the chambers and slots to equalise drag on the oil sheet allowing the oil sheet to be driven further prior to its breakup.

The adjustment means of the nozzle preferably comprises a plurality of threaded screws longitudinally spaced along the body member to exert a cantilever pressure through the body member urging a portion of the first and second lips of the nozzle outlet to narrow or widen upon threaded adjustment of each of said plurality of said adjustment screws.

To allow selective excitation of the to-be-vaporised components, the distillation chamber of the present invention preferably includes a microwave transmission device disposed for transmission of microwaves into the oil as it enters the top of the distillation chamber. The microwave transmission selectively excites the volatile components to promote vaporisation.

Preferably with the invention, a plurality of parallel, closely spaced, thin, liquid oil sheets are formed and driven downwardly at a relatively high velocity in the distillation chamber. A vacuum source at the top of the distillation chamber causes the distillation vapours to move rapidly upwardly between the sheets of oil. This method increases the speed of vaporisation by increasing the liquid surface to which an effective vacuum is supplied, by decreasing the static pressure directly adjacent to the liquid surface, by increasing the relative velocity pressure between the vapour and liquid, and by reducing or eliminating the fluid film at the oil surface which normally inhibits vaporisation. The method likewise decreases the distance through the liquid body through which the distillates must travel before being liberated at the liquid surface.

Preferably the vacuum source at the top of the distillation chamber is a pump which does not introduce steam into the distillation vapours. A liquid ring pump sealed by oil or fat from the process is preferred.

In the deaeration, dehydration and distillation of all hydrocarbons, the present invention does not utilise stripping steam. This improves vaporisation since the steam itself inhibits vaporisation by increasing the pressure at the liquid surface and by increasing the volume of vapours to be removed from the chamber. The present invention likewise does not utilise eductor steam to create vacuum in the system. Such eductor steam puts undue mass burdens upon the vacuum effects subsequent to the primary vacuum device which vitiates the effectiveness of all vacuum systems.

In connection with the distillation of edible oil and fats, the vapour products produced by the present invention can include water, air, tocopherol, fatty acids, alcohols, ketones, aldehydes and other materials.

The method of the present invention is especially useful for distillation of free fatty acids from triglycerides since it provides a fast and efficient distillation which reduces the number of free fatty acids formed as a result of degradation of triglycerides during deodorisation. The method of the present invention allows use of lower heat exchanger skin temperatures while still providing an extremely short residence.

The method also preferably includes a unique vapour system. Vacuum devices which do not add mass to the system, such as liquid ring vacuum pumps, are used instead of steam eductors of the prior art to provide vacuum to the distillers. This maintains a low vapour pressure and more efficient vacuum in the vapour recovery system. It also allows direct condensation of desirable products such as tocopherol, fatty acids, etc. Staging of the liquid ring pumps, use of the countervelocities in the distillation chambers and condensation of the vapours greatly improve the efficiency of applying vacuum to the liquid for distillation.

As an example of an isothermal station of the type used with the continuous process of the present invention, the tocopherol distillation station will now be described. Prior to this station, all aldehydes, alcohols, etc have been removed from the unfinished oil or fat so that the next volatile component, tocopherol, remains in solution in the oil and fat, but no components with a lower boiling temperature remain. As the oil or fat is moved into and heated to the temperature of the next isothermal station, only hydrocarbons at or above the boiling temperature of tocopherol will go overhead. The overhead vapours are conveyed to a rectifying column which produces virtually pure tocopherol. The tocopherol is separated as a pure product suitable for sale as is. The liquid ring vacuum pump above the rectifying column is sealed with the liquid phase tocopherol product as any other sealant would contaminate the pure tocopherol produced. The production of tocopherol in this isothermal station occurs continuously as all other processes, such as removal of free fatty acids, also are continuously proceeding.

This process can be continuous with low residence time due to the efficiency of distillation produced by the driven sheet method of distillation. This driven sheet method provides a large surface area subjected to both low pressure and to high velocity distillation vapours moving upwardly in the distillation chambers. Accordingly, no single station is a constant limiting factor in the complete refining and deodorisation.

In order to provide efficient condensation of the low volume, low flow, tocopherol the present invention circulates the distilled tocopherol vapour through a condenser having separated upper and lower sections. Vapour in the upper section is continuously recirculated over condensing coils at a rate sufficient to produce turbulent flow for good heat transfer. Liquid condensing in the upper section moves through a liquid seal to the lower section where a level control pump can removed product tocopherol from the process.

Although all other isothermal stations of the method of the present invention do not use steam, a final subsection does utilise stripping steam but not eductor steam. This final subsection is provided to remove peroxides and hydroperoxides. This steam stripping subsection is supplied with superheated steam to eliminate thermal shock upon the oil which occurs by the use of saturated steam at almost any practical pressure.

Preferably, the stripping chamber has disposed at its lower end beneath the normal liquid level a special distribution device (for distribution of superheated steam evenly throughout the liquid in the stripping chamber) which maximises the ratio between the surface area of the steam to its mass for the purpose of rapid reaction with the peroxides and hydroperoxides.

The invention will be more clearly understood from the following description which is given by way of example only, with reference to the accompanying drawings, in which:-

Figure 1 shows a schematic view of a process of refining fats and oils in accordance with the present invention.

Figures 2A-2F show a more detailed schematic view of the process of Figure 1.

Figure 3 is a partial side view of a distillation column constructed in accordance with the present invention.

Figure 4 is a plan view of the column of Figure 3 with the top removed.

Figure 5 is a side view of a portion of a distillation column nozzle constructed in accordance with the present invention.

Figure 6 is a cross-sectional view of the portion of a nozzle shown in Figure 5 taken along the lines shown in Figure 5.

Figure 7 is a cross-sectional view of the portion of a nozzle shown in Figure 5 taken along the lines shown in Figure 5.

Figure 8 is a cross-sectional view of the portion of a nozzle shown in Figure 5 taken along the lines shown in Figure 5.

Figure 9 is an end view of a nozzle constructed in accordance with the present invention.

Figure 10A is a cross-sectional view of the nozzle shown in Figure 5 taken along the lines shown in Figure 5.

Figure 10B is a cross-sectional view of the nozzle shown in Figure 5 taken along the lines shown in Figure 5.

Figure 10C is a cross-sectional view of a nozzle insert piece for the nozzle shown in Figure 10A.

Figure 11 is a schematic side view of a nozzle arrangement in a distillation column of the type shown in Figure 2.

Figure 12 is a schematic side view of a steam stripping column of the present invention.

Figure 13 is a cross-sectional view of a steam distributor of the steam stripping column of Figure 12.

Figure 14 is a cross-sectional view of a tip of a tube of the steam distributor of Figure 13.

Figure 15 is a side cross-sectional view of a portion of a surface condenser of Figure 2D.

Figure 16 is an enlarged schematic view of a portion of the process shown in Figures 2A -2F.

Figure 17 is an enlarged schematic view of a portion of the process shown in Figures 2A -2F.

Evaporation and distillation are surface dependent and influenced by the vapour pressure and the vapour motion adjacent to the liquid surface. Thus, a lower vapour pressure produces a faster evaporation and a faster vapour motion adjacent to the liquid surface produces a faster evaporation. With respect to the vapour motion, the influence of vapour motion on evaporation rates increases as the vapour pressure above the liquid surface decreases. This is because one aspect of evaporation is convection of the evaporated molecules away from the liquid surface and convection proceeds faster with a faster vapour motion adjacent to the liquid surface.

It is also well known that liquids have a fluid film which acts as a barrier to vaporisation. Movement of vaporised molecules away from the fluid film requires a force applied to the film and most distillation processes are relatively inefficient in applying this force.

The present invention avoids the problems of the prior art by providing a distillation chamber having a plurality of relatively narrow and elongated nozzles at the upper end thereof to drive relatively thin sheets of oil or fat downwardly in the chamber. These sheets are parallel to each other and closely spaced to improve the velocities of the vapour counterflow. The nozzles are precise to maintain the integrity of the sheets for as long as possible as they move downwardly in the chamber.

Thus, the distillation of oil and fat provided by the present invention employs closely-spaced unsupported sheets of oil driven at high velocity through a vacuum chamber.

The present invention also utilises a multiplicity of vacuum chambers in series for each of the distillations. In this way, not one but several vacuum sources can be applied to a distillating volatile product. This increases the surface area to which the vacuum source is applied and provides flexibility for oil having greater or less quantities of a particular distilled component.

Referring now to FIG. 1 and FIGS. 2A-2F, a complete refining and deodorizing process in accordance with the present invention is shown - schematically. As shown, degumming, deaerating, dehydrating, bleaching, low temperature refining, tocopherol distillation, the fatty acid distillation, and steam stripping all occur simultaneously at five isothermal stations. At isothermal station 10, degumming, dehydration and deaeration occur at approximately 160°F. At isothermal station 12 bleaching occurs at approximately 230°F. At isothermal station 14 refining distillation to remove ketones, aldehydes and other components occurs at approximately 285°C. At isothermal station 16 tocopherol distillation occurs approximately 290°F as measured at the top of the tocopherol rectifying column. At isothermal station 18 fatty acid distillation occurs at approximately 490°F. Finally at subsection 20 of isothermal station 18, steam stripping occurs to remove peroxides and hydroperoxides at approximately 490°F.

Between each of the stations having a different temperature and at the beginning of the process is a heat exchanger exchanging heat from the finished oil to the unfinished oil moving into the next station.

After startup, assuming a relatively well insulated set of equipment, relatively little heat is lost as waste heat. No significant amount of oil or fat product heating or cooling is required throughout the process.

Raw oil enters the process through stream 22. It exchanges heat within heat exchanger 24 with a stream 26 of finished oil or fat leaving the system. The unfinished but now heated oil in stream 22 then enters isothermal station 10 for degumming, dehydration, and deaeration. Water and air exit the isothermal station 10 at a stream 28. The unfinished but now degummed, deaerated, and dehydrated oil in stream 22 then exits isothermal station 10 and enters heat exchanger 30. At heat exchanger 30, the unfinished oil in stream 22 again exchanges heat with the product oil 26.

The unfinished oil in stream 22, then enters the isothermal station 12 for bleaching.

Following bleaching the unfinished oil in stream 22 is conveyed to heat exchanger 32 where the unfinished oil again exchanges heat with the finished oil in stream 26. This further heated unfinished oil then enters isothermal station 14 for a relatively low temperature distillation for removing aldehydes, ketones, alcohols, and those components boiling at a temperature less than the temperature of removal of tocopherol. The removed components exit in stream 34 and the unfinished oil, following the removal of these components continues in stream 22 to heat exchanger 36.

In heat exchanger 36 the unfinished oil again exchanges heat with finished oil raising its temperature for distillation of tocopherol in the isothermal station 16. The isothermal distillation in station 16 produces an essentially pure stream of tocopherol 38. This pure tocopherol is a very valuable product of the present invention and this product is not achieved in this manner by any of the prior art. Following removal of the tocopherol the unfinished oil from station 16 enters a heat exchanger 40.

Following a final heat exchange between unfinished oil and finished oil in heat exchanger 40, the unfinished oil enters an isothermal station 18 for distillation of free fatty acids. The free fatty acids exit the isothermal station 18 in stream 42. Preferably, the free fatty acids are then fractionated and condensed into the several free fatty acids fractions.

The unfinished oil from station 18 then enters the final subsection 20 of isothermal station 18. The subsection 20 is a part of isothermal station 18 although it performs the stripping function while the balance of isothermal station 18 does not. It is necessary to keep separate the steam vapor products found in the subsection 20 from the balance of isothermal station 18 so that free fatty acid products may be discretely recovered.

In subsection 20 of isothermal station 18, the unfinished oil is steam stripped to remove peroxides and hydroperoxides from the triglycerides. The water, peroxide and hydroperoxide vapors leave the subsection 20 by steam 44 and the finished oil leaves subsection 20 in stream 26.

Referring to FIGS. 2A through 2F as well as FIGS. 16 and 17, an example continuous edible oil distillation process of the present invention is shown schematically in more detail. Heat exchangers 24, 30, 32, 36 and 40 are redundantly shown on appropriate pages of the drawings to aid in understanding the flow connections. Distillation chambers 51-56, 61-64, 71-74, 81-88 and 91-94 are all vacuum distillation chambers utilizing driven sheets as described above. The chamber top and the nozzle construction and arrangement are shown in greater detail in FIGS. 3 through 11. The steam stripping column components which relate to the addition of steam are shown in greater detail in FIGS. 12 through 14.

Unfinished oil continuously enters the system through stream 102 driven by metering pump 104. An example of unfinished oil would be finely screened soybean oil. This unfinished oil would have about 0.4% free fatty acids and 0.1% tocopherol with the balance being essentially triglycerides. Other components such as phosphatides, chlorophyll, and dissolved oxygen are also present in small quantities. As the unfinished oil enters at stream 102 it typically has a temperature of approximately 70°F.

The unfinished oil in stream 102 enters a heat exchanger 24 where the unfinished oil exchanges heat with finished oil which enters the heat exchanger in stream 106 and exits the heat exchanger at stream 108. The finished oil in stream 106 typically has a temperature of 170°F and stream 108 typically has a temperature of 80°F.

The unfinished oil which exits exchanger 24 exits in a vapor stream 110 and a liquid stream 112. The vapor stream 110 and the liquid stream 112 are both approximately 160°F. The liquid stream passes through a contactor 114 which allows additional vapor from the unfinished oil to enter stream 110. A liquid stream 116 exits the contactor 114. The liquid stream of unfinished oil which has been heated to approximately 160°F enters a heat exchanger 118 which provides trim heat or start up heat to the oil prior to entering blender 122. Saturated steam is provided to heat exchanger 118 by means of stream 120.

Following heat exchange in heat exchanger 118, stream 116 of unfinished oil passes through a blender 122, a high speed mixer 124, and a centrifuge 126 for the addition and removal of phosphoric acid and water. This removes phosphatides and some water from the unfinished oil stream 116. This is the first stage of degumming.

The stream 116 is pumped by a pump 128 through a trim heater 130 prior to entering the top of vacuum distillation chamber 51. The trim heater 130 supplies small amounts of heat to the unfinished oil with steam or electrical energy or heat from a side stream of finished oil. After trim heating the stream 116 enters a microwave exciter 132 at the top of chamber 51. The microwave exciter 132 selectively excites the water and more volatile components of the unfinished oil compared to the triglycerides and less volatile components. Little heat is transferred into the unfinished oil by the microwave exciter as the exposure of the oil to it is extremely short. Nevertheless, the selective excitation of the more volatile components promotes distillation without harming the oil. The configuration of the microwave exciter with respect to the nozzles in the upper portion of the vacuum distillers is described in more detail below.

The pump 128 supplies constant pressure (this constant pressure is adjustable to allow proper sheet configuration of the oil) to the oil or fat in the nozzles in the top of chamber 51. This importantly allows each nozzle to produce a uniform, thin sheet of oil. A constant pressure valve 134 is provided in stream 116.

Providing vacuum to vacuum distillation chamber 51 is a liquid ring vacuum pump 136. The suction side of the pump is connected to the top of vacuum distillation chamber 51. The discharge of the pump 136 is into the vapor stream 110 which exits the heat exchanger 24.

At the bottom of chamber 51 is a level control 138. The effluent 142 at the bottom of chamber 51 has the static vapor pressure of the chamber itself plus the liquid head pressure of the height to the liquid surface. Hence, pump 144 is a magnetically driven pump with no shaft seals through which atmospheric air may leak into pump. Pump 144 pressures the unfinished oil to 35 to 50 pounds per square inch. Thus, mechanical seals are permissible for the higher pressure pumps (such as pump 128 and 143 and equivalent pumps on the remaining distillation chambers).

Likewise all valves in the liquid flow will have a pressure greater than atmospheric and, hence, will not allow air to contaminate the liquids passing therethrough. An orifice plate 145 is placed in stream 146 upstream from the check valve 148. Its purpose is to flow preferentially larger portions of the unfinished oil in the direction of the valve 140, thus requiring pump 128 to receive nearly all of its suction flow from the unnumbered flow 116 from the centrifuge 126. This arrangement together with the other flow controls and valves is capable of discharging the exact flow it receives from any component. When the entire apparatus is operating at full capacity, little flow passes through stream 146 or similar streams. In other words, this arrangement provides flow control through all components established by metering pump 104.

As is apparent from the drawings, each of the distillation chambers 51-56, 61-64, 71-74, 81-88 and 91-94 has similar apparatus for flowing oil in driven sheets, heating, level control, suction and reflux. Therefore, the apparatus descriptions for each of the remaining chambers will not be described since it is the same as that described for chambers 51 and 52.

The outlet stream 142 of unfinished oil from distillation chamber 51 enters a second distillation chamber 52 which is in series with distillation chamber 51. Together these distillation chambers provide a first dehydration and deaeration of the unfinished oil. A major portion of the water and dissolved oxygen are removed from the oil in chambers 51 and 52.

A liquid ring vacuum pump 150 provides vacuum to chamber 52. The liquid and vapor effluents from both vacuum pumps 136 and 150 is to the vapor stream 110. The stream consists of water vapor, air, unfinished oil used for liquid ring pump sealant and unfinished oil entrainment. In fact, a small amount of entrained oil is needed if the system is to operate at its highest efficiency. The driven sheets of oil must be driven at very high velocities in order to obtain the maximum benefit of the vaporizing efficiencies unique to this process. Such high velocities cause parts of the driven sheets of oil or fat to shear creating small particles to be entrained in the rising vapors.

Following dehydration and deaeration in chambers 51 and 52, the unfinished oil enters a blender 152, a high speed mixer 154, and a centrifuge 156 where malic acid and some water are added and removed. This further removes phosphatides from the unfinished oil. This second stage of degumming is more efficiently accomplished with the removal of water which was achieved in chambers 51 and 52.

Following the second stage degumming, unfinished oil then is conveyed through distillation chambers 52 through 56 in series for further deaeration and drying. The oil at this stage should be completely deaerated because of its vulnerability to auto-oxidation following degumming. Liquid ring pumps 158, 160, 162, and 164, supply vacuum to each of the distillation chambers 53, 54, 55 and 56 respectively, and exhaust water, oxygen, liquid ring pump sealant and entrained oil or fat to stream 110.

Referring especially to FIG. 17, the overhead vapors stream 110 which gathers the distilled vapors from chambers 51-56 enters the suction side of a liquid ring vacuum pump 166 which provides an improved effective vacuum to the chambers 51-56. The pump 166 drives a liquid and vapor stream 177 to a bubble-cap column 168. A vertical stream 196 which is a continuation of streams 110 and 194 carries the liquid phase materials which may condense or which are carried as entrainment in streams 110 and 194 to bubble-cap column 168. These liquids consist of any condensed vapors, unfinished oil entrainment having come out of entrainment and the liquid ring pump sealant of unfinished oil. The conduit through which stream 110 flows should be sloped to allow liquid which flows therein to move rapidly to vertical stream 196, preventing liquid from filling the conduit and from entering pump 166. Liquid from stream 196 must enter the column below a point where the pressure in stream 110 and the discharge pressure from vacuum pump 166 are balanced with the liquid head of the unfinished oil.

The bubble-cap column 168 separates less volatiles and the entrained oil (as much as 0.5% of the product flow is desirable) which enter stream 110 and a portion of this oil is supplied through stream 170 as a sealant to the liquid ring pumps 136, 150, 158, 160, 162, 164, and 166. The sealant oil to these pumps is moved by a pump 157 and is cooled by a cooler 169 fed by cooling water in stream 171.

Flow of sealant oil to the pumps 136, 150, 158, 160, 162 , 164 and 166 is limited by constant flow valves 137, 151, 159, 161, 163, 165 and 167 adjacent each pump. This maintains the proper amount of sealant to each pump.

A recirculation stream 172 is provided on bubble-cap column 168. A trim heater 174 and a pump 176 are provided for heat and circulation of this stream 172. This recirculation prevents water from exiting the bottom of column 168.

Vacuum is applied to the top of bubble cap column 168 by a liquid ring vacuum pump 180. Water and oxygen which exit overhead of the bubble-cap column 168 are conveyed to a phase separator 178 through vacuum pump 180. The vacuum pump 180 is sealed with water through stream 183 condensed in the bottom section of the phase separator 178. The sealant water 183 is pumped to the vacuum pump 180 by pump 179 through heat exchanger 181 cooling the stream 183. Cooling water flow 171 is provided to exchanger 181 for the cooling.

Entrained oil which is not utilized as sealant to the pumps is conveyed to the stream of unfinished oil 102 entering station 10, by means of stream 184. A level control 186 is provided at the bottom of bubble-cap column 168 and a valve 188 on stream 170 opens and closes responsive to the level control 186. Pump 157 motivates the flow. Stream 184 is driven by a product transfer pump 185 along with four valves 187, 189, 191 and 193 which allow the pump 185 to flow the unfinished oil or fat in the direction of the incoming stream 102 or the next station 12. This arrangement is used in start-up for establishing the initial temperature of the respective isothermal stations by flowing to the left. The arrangement of the pump 185 and valves 187, 189, 191 and 193 on conduit 184 and conduits similar to conduit 184 in other isothermal stations also have the purpose of evacuating the isothermal station when flowing to the next station. By stopping flow through metering pump 104 and refluxing the contained oil or fat within the isothermal station by flowing stream 184 to stream 102, the oil in each station may be refined to the degree to which that respective station is capable. Once the entire containment of the isothermal station is thusly refined or deodorized, flow to the next station evacuating the present station is accomplished by the various transfer pumps such as pump 144 and pump 185 on stream 184. Hence, the disclosed apparatus and system are capable of refining and deodorizing to completion all of the oil or fat contained in each individual station as well as continuously through all stations.

Likewise, it is unnecessary to evacuate the entire five isothermal stations to change an oil or fat product. By evacuating one station and allowing its chambers and piping to drain, the containment therefrom is evacuated forward into subsequent processing of the first oil or fat. While the evacuation process proceeds, partial reflux takes place through streams such as stream 184. The second oil or fat is introduced into the now evacuated isothermal station. With this sequence, the second oil or fat is continued throughout the entire apparatus while it still enjoys most of the heat transferred from the leaving first oil or fat.

Referring still to FIGS. 2A-2F, the unfinished oil which has been deaerated and dehydrated in chambers 51-56 enters heat exchanger 30. Heat exchanger 30 exchanges heat from a finished oil stream 190 entering the heat exchanger 30 at approximately 230°F. Any vapors released by the increase in temperature from the oil or fat are carried in stream 194 which is provided at the top of exchanger 30 allowing the vapors to exit exchanger 30. Stream 194 flows vapors to stream 110 and both are connected to vertical stream 196.

Stream 192, at approximately 230°F, enters a mixer 200 where dried and deaerated clay are mixed with the oil for bleaching. A heat exchanger 202 on stream 192 is provided for trim heating. Stream 192 then enters a first set of pressure filters 204 which are provided in parallel on this stream to remove the clay, chlorophyll, and color chemicals from the stream. A level controlled tank 206 is disposed on stream 192 prior to filters 204 and is connected to a valve 208 downstream of filters 204 to maintain the flow through filters 204 at the rate oil is supplied to filters 204. The unfinished oil from filters 204 then enters a second level control tank 210 and a second set of pressure filters 212 disposed in parallel. The second set of filters are polishing filters which further remove the clay and color chemicals. The pressure filters and the devices for adding deaerated clay are well known in the bleaching art. Recycle, if necessary or desired in the bleaching isothermal station can be provided in stream 216.

Unfinished oil in stream 214 from the second set of filters 212 enters a heat exchanger 32 for again exchanging heat with finished oil. Unfinished oil enters heat exchanger 32 in a stream 214 at approximately 230°F and exits heat exchanger 32 in stream 302 at approximately 285°F. The finished oil enters heat exchanger 32 via stream 304 at approximately 295°F and exits via stream 190 at approximately 240°F. Vapor from the unfinished oil stream which enters heat exchanger 32 can exit the heat exchanger in a stream 306. Liquid in stream 302 enters a contactor 308 to further allow vaporization and the vapor from this contactor enters stream 306.

The stream of unfinished liquid oil 302 is conveyed through distillation chambers 61-64 connected in the same manner as distillation chambers 53-56. At this isothermal station, distillation chambers 61-64 remove all components more volatile than tocopherol. These components are essentially alcohols, aldehydes and ketones. Liquid ring pumps 310, 312, 314 and 316 provide suction to the top of chambers 61-64. Entrained oil, sealant oil and vapors are conveyed to bubble cap column 318 by liquid ring pump 320 for separating and recycling the entrained oil and supplying unfinished oil for sealant to the liquid ring pumps. Liquid ring pump 324 conveys overhead vapors of aldehydes, alcohols, etc. to a phase separator 322. The liquid ring pump 324 uses a special sealant suitable for high temperature which is collected at bottom of phase separator 322 and pumped by pump 323 through exchanger 325 where it is cooled by cooling water 171.

The underflow unfinished oil from the distillation chambers 61-64 is conveyed via stream 326 to heat exchanger 36. This again provides heat exchange between the unfinished oil and finished oil. The unfinished oil enters at approximately 285°F and exits in stream 402 at approximately 300°F or a temperature which will produce a 290°F temperature at the top of rectifying column 412. Tocopherol will vaporize at this temperature.

Following heat exchange in heat exchanger 36, the unfinished oil is conveyed to distillation chambers 71-74 for removal of tocopherol. The distillation chambers 71-74 are of the same type and have the same apparatus configurations as the distillation chambers 53-56 and 61-64. Liquid ring pumps 404, 406, 408 and 410 are connected on their suction side to each respective distillation chamber. The liquid ring pumps are sealed with entrained oil separated in a rectifying column 412 from the overhead from distillation chambers 71-74. A rectifying column 412 with many trays is used in order to separate relatively pure tocopherol from free fatty acids. The lower four trays of the rectifying column are used for entrained oil separation.

A reflux circulator and heater 414 is provided on the side of rectifier 412 to heat the oil for rectifying and to continuously recirculate oil from the bottom of the rectifying column 414 to the fifth tray of the column. This ensures that all rising vapors entering the rectifying column encounter downwardly flowing heated oil.

A second reflux circulator and heater 416 extends between the sixth and eighth trays of the rectifying column 412 again heating and recirculating free fatty acids from a lower portion of the rectifying column 412 to a higher portion. A product recovery tank 418, is attached to the sixth tray to recover lower boiling temperature free fatty acids which will rise in the rectifying column to this tray. A vapor connection 420 extends from the product recovery tank 418 to the rectifying column 412 to equalise pressure in the 448 as liquid enters and leaves the tank responsive to a level control in the tank.

A level control 422 is disposed in the bottom of rectifier 412 to control the level of oil which is retained in the rectifier 412. A pump 424 pumps the excess oil back to stream 322, entering heat exchanger 36 by way of stream 426. The flow through stream 426 is controlled by a valve 428, responsive to the level control 422.

Pump 424 also pumps oil to liquid ring pumps 404, 406, 408, 410, and 411 as sealant. The sealant oil is cooled prior to entering the pump by a cooler 430. Constant flow valves just pror to each pump control the flow of sealant to the pumps.

A liquid ring pump 432 provides suction to the top of rectifier 412 and is sealed by tocopherol product from a surface condenser 434. By using pure tocopherol as sealant to the pump 432 the overhead vapors from the rectifier 412 are not contaminated. The outlet of the liquid ring pump 432 supplies essentially pure tocopherol to the surface condenser 182.

The tocopherol vapors from rectifier 412 are conveyed to sur face condenser 434 through stream 438. The tocopherol stream 438 enters the top of surface condenser 434 and moves over the coils of the surface condenser fed by the cooling water stream 171. The flow of tocopherol in stream 438 is very slow and yet it is desirable to have turbulent flow of vapors over the coils to improve heat transfer. Accordingly, magnetically driven vapor recirculation blowers 440 recycle vapors from the bottom of condenser 434 to the top of condenser 434 at a rate sufficient to provide turbulent vapor flow over the coils. The blowers are magnetically driven to prevent any air contamination of the tocopherol due to failing blower seals.

Referring also to Fig. 15, it can be seen that the bottom of the surface condenser 434 is divided into two areas or chambers 442 and 444 by a plate 446 which slightly slopes to the center across the bottom of condenser 434. The two chambers plus the adjustable cup liquid seal between them, provide a controlled pressure differential favoring the upper chamber with higher pressure to aid the vapor reflux flow by the blowers. The very small amounts of tocopherol vapor conveyed to and exiting from pump 436 form a vapor stream 437, are mixed with vapors unable to be condensed in the next isothermal station and are gathered in a tank 439. Liquid from tank 439 is pumped through a chiller 441 and returned as sealant to pump 436 by a stream 443.

A pipe 448 extends down from the center of plate 446 into a cup 450 which is filled with tocopherol liquid condensed from the upper chamber 442. As more tocopherol condenses the liquid overflows the cup and falls into lower chamber. The liquid in cup 450 extends about the lower end of pipe 448 to seal the upper chamber 442 from the lower chamber 444. The pressure differential between chamber 442 and chamber 444 is the liquid height in the cylinder 448.

The cup 450 is supported by a threaded central rod 452 which is fixed to spiders 454 and 456 in cylinder 448. By threaded movement of the cup 450 on the rod 452 the height of liquid in cylinder 448 can be adjusted which, in turn, adjusts the pressure differential between chambers 442 and 444.

Liquid tocopherol gathers in the lower chamber 444 of the condenser 434 and the level of this liquid is controlled by a level control 458. A pump 460 is provided to draw the tocopherol from this liquid in condenser 434 by way of stream 462. A valve 464, responsive to the level control 460, controls flow in stream 462. Pump 460 also supplies tocopherol sealant to liquid ring pump 432 through stream 466.

As can be seen, six different effects of vacuum energy are applied to provide a vaporization of and separation of tocopherol from unfinished oil. The first effect is the counter velocities between the liquid surfaces of the driven sheets of oil or fat and the vapor velocities leaving overhead each distillation chamber. The second effect is the liquid ring pumps 406 through 410. The third effect is the liquid ring pump 411 connected to the outlet of pumps 406 through 410. The fourth effect is the liquid ring pump 432 providing suction to the rectifier 412. The fifth effect is the surface condenser 434 which provides suction due to condensation of the tocopherol vapors. And, finally, the sixth effect is the liquid ring vacuum pump 436 which provides suction to the surface condenser 434. By means of the staged vacuum sources, an increased efficiency for each is achieved.

Referring now to FIG. 2E, the unfinished oil from the tocopherol distillation chambers 71 through 74 enters heat exchanger 40 via stream 468 at approximately 300°F and exits via stream 502 at approximately 480°F. Finished oil at approximately 490° enters the heat exchanger 40 via stream 504 and exits via stream 470 at approximately 310°F.

As with the previously described isothermal stations, the fatty acid distillation station flows the unfinished oil through distillation chambers producing a vapor (mainly free fatty acids but also including some entrained triglycerides) and a liquid unfinished oil. This station also includes a similar six effect vacuum system for supplying the vacuum for distillation. The configuration of the pumps, distillers, and surface condenser are essentially the same as described in the separation system for tocopherol. In place of the rectifier 412 is a fractionator 510. This allows separation of free fatty acids having different boiling temperatures and provides for discrete product separation and removal. Separate free fatty acids taken from various trays of fractionator 510 exit in stream 512, 514, 516 and 518 as well as from the bottom of the surface condenser.

The unfinished oil from the distillation chambers 81 through 88 is conveyed at approximately 490° as underflow from the distillation chambers in stream 520. Citric or malic acid is added to the stream 520 by a mixer 522 to separate the peroxides and hydroperoxides at the double carbon bonds of the unsaturated oils or fats.

The underflow unfinished oil in stream 520 is then conveyed to the stripping steam station for removal of peroxides.

The distillation-stripping chambers 91 through 94 receive the unfinished oil from stream 520 in series and are essentially the same as the other distillation chambers described above except for the addition of a stripping steam distributor located at the bottom of the chambers. Stripping steam enters each distillation-stripping chamber at approximately 500°F through a capillary distributor described in more detail below. The level of liquid in the distillation-stripping chamber is maintained higher in the chamber to allow the necessary percolation of steam through the oil in the chamber. The tops of the chambers still include nozzles for driving sheets of the unfinished oil as necessary for efficient distillation.

Liquid ring vacuum pumps provide vacuum to each of the distillation-stripping chambers 91 through 94. The pressure side of these pumps is connected to the suction of a liquid ring pump 602 which conveys the overhead flow from the distillation-stripping chambers 91 through 94 to a bubble-cap column 604 for removal of entrained oil. The entrained oil recovered in the fatty acid distillation station are conveyed back to stream 468 by stream 606. A liquid ring pump 608 provides vacuum to the bubble-cap column 604.

Peroxides and hydroperoxides and stripping steam are conveyed through vacuum pump 608 and into phase separator 610. The peroxides, hydroperoxides and the stripping steam are vented to the atmosphere through stream 44. A special high temperature sealant is returned to the liquid ring pump 608 by pump 611 after being cooled in exchanger 613.

Super-heated stripping steam is provided to the distillation-stripping chambers 91 through 94 by a boiler 620 and a super-heater 622. Boiler 620 supples saturated steam for the super-heater 622 as well as to various start-up and temperature trimming heat exchangers in various isothermal stations in the process. Super-heater 622 supplies high temperature super-heated steam for steam stripping and start-up and temperature trimming heat for the fatty acids isothermal station. Boiler 620 receives the non-condensibles from the low temperature refining, tocopherol and the fatty acid isothermal stations for complete oxidation by combustion in the furnace section of boiler 620.

Referring now to FIGS. 3, 4 and 11, the top of a distillation chamber 700 (such as 51-56, 61-64, 71-74, 81-88 or 91-94) is shown. A typical distillation chamber 700 would have a height of approximately 3 meters and a diameter of approximately 0.7 meters. An incoming stream of oil enters the top of the distillation chamber 700 through a riser conduit 702. The riser conduit 702 is connected to a pair of horizontal conduits 704 and 706 which split the stream for entering on opposite sides of the distillation chamber 700. As the oil stream enters the opposite sides of the distillation chamber 700, it enters a manifold 708 which spans the diameter of distillation chamber 700 from the conduit 704 to the conduit 706. Extending downwardly from manifold 708 is a plurality of supply tubes 712 which enter each of the top central portions of each of the nozzles 712.

The nozzles 712 are disposed parallel to each other and are all normal to the manifold 708. Each nozzle is staggered in its height with respect to its adjacent nozzle so as to allow closer packing of the nozzles as well as to allow unrestricted flow of the vapors to the primary liquid ring vacuum pump. Of course, the sheets of oil 714 driven by the nozzle must not contact the adjacent nozzles. The ends of each nozzle 712 are held by a clamp or ring 716. In this manner, the nozzles are held fixed for uniform and constant driving of the oil sheets 714. A typical speed for a sheet of oil from each nozzle would be approximately from 1 to 50 meters/sec.

A liquid ring vacuum pump 718 is connected to a conduit 720 which is disposed in the upper center of a cap 722 of distilla tion chamber 700. As the vacuum pump 718 provides vacuum to the distillation chamber 700, the source of vacuum is, therefore, directly above the nozzles 712 which drive the sheets of oil 714 downwardly in the distillation chamber 700. A typical vacuum pressure at the vacuum pump 718 may be as high as 25mm Hz.

A pair of microwave exiciters 724 are attached to conduits 704 and 706 adjacent to the entrances to distillation chamber 700. These microwave exciters face each other through manifold 708. Conduits 704 and 706 open to the microwave exciters 724 through plates 730 which are transparent to microwaves but, of course, prevent the oil from entering the microwave devices 724.

Referring to FIGS. 5 through 10, a nozzle 800 - (such as 712 in FIGS. 4 and 11) is shown in more detail. Each of the nozzles 800 has a pair of mated halves 802 and 804. Nozzle halves 802 and 804 are joined at their upper midportion by threaded bolts 806 and on their ends by threaded bolts 808. A spacer 810 separates the two halves 802 and 804 and, in part determines the thickness of a sheet of oil extruded from the nozzle 800.

Each of the nozzle halves 802 and 804 has a central tube 812 and 814, respectively, extending from a central cavity through the midportion of the top of the nozzle half. The tubes 812 and 814 are joined to a single tube 816 which, in turn, joins the manifold in the top of the column (such as manifold 708 in FIG. 4). Thus, liquids moving from the manifold to the tube 816, the tubes 812 and 814 and finally, an opening or chamber 820 at the center of nozzle 800. From chamber 820, the liquid must pass through additional chambers 822, 824, and 826 before exiting the nozzle 800 at the opening slit 828. Each of the chambers 820, 822, 824 and 826 are defined by mated grooves on the adjoining surfaces of nozzle halves 802 and 804.

Each of the chambers 820 through 824 is connected to its adjacent chamber so as to promote uniform pressure and distribution of liquid flow longitudinally in the nozzle. First, the chamber 820 is connected to chamber 822 by an inclined opening 830. By inclined is meant that the opening is wider at the edges of the nozzle halves 802 and 804 than at the midportion of these halves with a constant taper therebetween. This helps to equalize the distribution of pressure and flow after the liquid enters the midportion of the nozzle 800 through tubes 814 and 816.

Chamber 822 is connected to chamber 824 by a slotted opening 832. A plurality of grooves or slots 834 extend vertically in the nozzle along the opening 832 to further equalize the pressure and flow of liquid longitudinally across the nozzle 800.

Chamber 824 is connected to chamber 826 by a uniform flat opening 836. This uniform opening evens the pressure differentials created by the slots 834.

The opening slit 828 allows liquid from chamber 826 to exit the nozzle 800. The width of this opening slit 828 can be precisely controlled by adjustment screws 840 provided at uniform distances across the upper edge of the nozzle 800. These adjustment screws 840 act to press apart the upper surfaces of the halves 802 and 804 narrowing the opening of 828 as the halves are moved apart. The pressure of the liquid as it moves through opening 828 acts to resiliently increase the size of opening 828 and act against screws 840. A constant pressure valve 842 controls the pressure of the oil supplied to each group of nozzles so as to maintain uniform pressure and, therefore, a relatively narrow, elongated uniform, oil sheet. The screws 840 are spaced longitudinally along the top of nozzle 800 to provide discrete longitudinal adjustment along the opening 828. The distance between each of the screws 840 can be changed to allow coarse or fine longitudinal adjustment.

In some instances, it is desirable to have a drag plate 846 (See FIG. 10C -plate 846 is not shown in FIG. 10A for clarity as to its design) to aid in maintaining integrity of the driven sheet from the nozzle 800. The purpose of the drag plate 846 is to exert a central, inner liquid drag force on liquid passing from the nozzle 800 reducing velocities at the central portion of the liquid sheet. This balances those forces on the surface of the liquid sheet which would tend to prematurely disrupt the sheet. The inner drag force balances the external drag force and the oil sheet driven from the nozzle maintains its integrity for a further distance from the nozzle.

The drag plate 846 has an elongated uniform cross section and a flat plate portion 850 extends from chamber 822 through chamber 826. Liquid passes evenly on each side of the plate as a result of liquid pressure. A triangular head portion 849 of drag plate 846 resides within chamber 822 and rests upon the inclined upper shoulders at slotted opening 832. This retains the drag plate 846 in place. The tip 852 of drag plate 846 extends to or beyond the nozzle lips at opening 828.

In preparing a nozzle for use in a column the nozzle is first fitted with a spacer 810 which partially determines the thickness of the sheet of oil which will be formed by the nozzle. Next, the nozzle is placed on a test bench for flowing of oil through the nozzle and fine tuning of the driven sheets produced by the nozzle. Adjustment of the oil pressure (by valve 842) and the screws 840 optimizes the thickness durability and uniformity of the driven sheet. This is crucial to allow the sheet to remain intact for sufficient depth in the column while being driven at high speeds. The nozzles are fitted one by one into the column and fine tuned in place.

Preferably, the nozzle halves 802 and 804 are formed of stainless steel which has been subjected to milling for the chambers and the inclination of opening 830 and the slots 834. However, for low temperature chambers and for a less expensive nozzle, the nozzle halves can be made of extruded aluminum and subjected to less milling. The nozzle lips at opening 828 can be covered with a nonwetting surface 844 of tetrfluoroethylene or the like to further improve the quality of the driven sheet.

Referring now to FIGS. 12 through 14, a distillation-stripping chamber 900 is shown. Of special importance to distillation-stripping chamber 900 is the method and device for distributing steam beneath the liquid surface 902. A sparging nozzle assembly 904 disposed in the bottom of column 900 is shown in more detail in FIG. 13 and a tube portion of the nozzle assembly 904 is shown in more detail in FIG. 14.

The sparging nozzle assembly 904 includes a hemispherical chamber body 906 closed at its lower end by a plate 908. A threaded opening 910 is provided in the center of plate 908 to allow superheated steam to enter the chamber 912 formed by the hemispherical body 906 and plate 908 through an attached pipe 914.

Extending through the hemispherical body 906 is a plurality of small tubes 916. Steam which enters the chamber 912 passes through the tubes 916 prior to entering the liquid in distillation-stripping chamber 900. The size of the holes in tubes 916 determines the size of bubbles formed in the liquid as steam moves into the liquid through the tubes.

Preferably, the size of the hole 918 in tubes 916 is of capillary size so that as fluid flows through the tubes the flow rate is mainly determined by the size of the hole 918 and the length of the tube 916. In other words, fluid or gas can not flow significantly faster than an optimum, rate because of the restriction of the tube size. A typical hole 918 would have a diameter of approximately .025 to .25 millimeters. This flow rate uniformity produces a uniform bubble size which allows the optimum surface area to mass ratio of the super-heated steam bubbles. Also, the capillary hole size 918 and the length of tube 916 prevent bubble explosion in the liquid since the super-heated steam enters the liquid near the static pressure of the liquid. This is important since bubble explosion makes a small bubble size impossible.

The tips 920 of the tubes 916 are tapered and sharpened to a cone to reduce contact of the formed bubbles with the tips 916. This prevents erractic growth which can occur when there is a large metal surface at the location of bubble initiation. Again, this creates a small and uniform bubble size.

Super-heated steam is conveyed to the chamber body assemby 904 by a pipe 914 threaded to the opening 916. The pipe 914 and its connected chamber body assembly 904 are cantilevered in the lower end of distillation-stripping chamber 900. A vibrator 922 is mounted on the pipe 914 to constantly vibrate the chamber body assembly 904 and the tubes 916. Preferably, the vibrator 922 vibrates the tubes 916 up to 60 kilohertz so as to decrease the bubble size produced by the tubes 916 and to make the bubble size small and uniform among the tubes.

The flow through an individual capillary tube is determined by three functions provided there is sufficient static pressure on the fluid to exceed the velocity friction losses. They are the capillary size, the tube length and the fluid viscoscity. These determinates will provide an upper limit to the individual tube flow regardless of how much pressure is applied to the fluid as long as it is above the velocity friction losses. Hence, when the design of a singular tube has been made and the fluid is selected (including temperature), its flow is also determined. The total or composite flow through as assembly such as sparging nozzle assembly 904, is the individual tube flow times the number of tubes in the assembly. Once an assembly flow is determined, the uniformity of the composite flow may be monitored with an extremely accurate flow measurement (even slight differential pressure changes across an orifice plate placed in the total flow) to determine if tube clogging or tube wash-out has occurred. With such an arrangement, the present invention safe-guards itself from malfunctions.

Preferably a warning device 932 is provided on conduit 926 to indicate plugging of the tube 916 or washout of the tubes 916.

The tubes 916 can be constructed of stainless steel and may be clad with a brazing material if desired.

The devices and methods described above have been described for the continuous refining and deodorizing as would be typical for salad oil. If desired, continuous hydrogenation could be added to this system for other oils. Continuous processes for the hydrogenation of edible fats and oils are part of the present state of the art and these proceses are completely compatible with the present invention. The inclusion of hydrogenizing processes would be placed up-stream of the final isothermal station. Continuous hydrogenation processes and equipment are shown in U.S. Patents No. 2,520,422; 2,520,423; 2,520,424; 3,792,067; and 3,634,471.

In the system described above, blended oil and fats are mixed in the unfinished stage in their proper ratios and are fully processed in the combined state. This is a departure with most of the present practices which process the oils and then blend.

One aspect of the present state of the art not compatible with the present invention is heat bleaching. This process calls for a long residence at a high temperature which is contrary to the present invention's objectives. As degradation of the refined and deodorized oil or fat is a function of time as well as high temperature, the present disclosure provides new control with extremely short retention time during the final isothermal station which produces a superior purity of oil and fat while, at the same time, eliminates degradation associated with all other processes.

The present industry practice is to produce the lowest absolute pressure at all costs which, unfortunately, ignores the dynamics of the vapor flow in relation with the fluid film establishment. Measurements of a few millimeters of mercury vacuum are possible at the primary vacuum device (not at one millimeter above a distilling surface of oil or fat) with the present state of the art.

However, this has little to do with the rate of distillation since the vacuum at the liquid surfaces where distillation occurs is much higher. The present invention does not attempt to produce a vacuum (measured statically) near this level as it finds that such is unnecessary.

Claims

1. A method of distilling a distillation product from raw edible oil characterised by the steps of forming a sheet of liquid edible oil having a relatively narrow thickness and a relatively large surface area; and moving said sheet of liquid edible oil in a distillation column at distillation temperature and pressure such that a distillation vapor product is formed therefrom and such that the surface of

said sheet of oil moves rapidly with respect to vapor in said distillation column to promote distillation.

2. A method according to claim 1 characterised in that there is a relatively low pressure at the top of said distillation column, and in that the liquid edible oil flows through an elongate, narrow nozzle disposed in the top of said distillation column such that said formed sheet moves downwardly in said column.

3. A method according to claim 1 or 2 characterised by directing microwave radiation onto said liquid edible oil prior to forming said sheet thereof.

4. A method according to claim 1, 2 or 3 characterised in that the vapour product is driven across the surface of the sheets to promote distillation and the sheets are in parallel and relatively closely spaced so that there is a relatively fast flow of vapour between them.

5. A method according to any preceding claim wherein the edible oil contains tocopherol and free fatty acids characterised by the steps of

(a) continuously supplying the edible oil to a first vacuum distiller and flowing said edible oil in driven sheets within said first distiller and distilling tocopherol from said edible oil; and

(b) continuously supplying, concurrent with step (a), edible oil from which tocopherol has been distilled in said first vacuum distiller to a second vacuum distiller and flowing said edible oil in driven sheets within said second distiller and distilling fatty acids from said edible oil.

6. A method according to claim 5 wherein the edible oil also contains air and water and/or lecithins and/or chlorophyll and/or hydrocarbons more volatile than tocopherol characterised in that the edible oil is continuously supplied concurrent with steps (a) and (b) to further vacuum distiller(s) or a bleaching device corresponding to said additional ingredients and said additional ingredients are vacuum distilled or removed from the edible oil therein and the edible oil from which said additional ingredients are removed is supplied to step (a).

7. A method according to claim 5 or 6 wherein the edible oil also contains peroxides and hydroperoxides which are removed in a steam stripper from the oil from which the fatty acids have been stripped.

8. A method according to claim 6 or 7 characterised by the step of continuously condensing said distilled tocopherol in a chamber having a vapour chamber and a separated liquid chamber, said vapour chamber having condensing surfaces therein and continuously recirculating tocopherol vapour through said vapour chamber so as to provide turbulent flow of said vapour across said condensing surfaces.

9. A distillation column nozzle for use in supplying a sheet of liquid in a distillation column and characterised by a central liquid inlet on one side, an elongated liquid outlet on the opposite side defined by first and second lips, a pressure equalisation means for communicating said inlet and said outlet and equalising liquid pressure longitudinally across said outlet; said pressure equalisation means comprising a plurality of longitudinal chambers connected by respective slots, respectively; said central liquid inlet being disposed for conveying liquid to a central portion of a first said longitudinal chamber; a first said slot connecting first and second said chambers having a relatively narrow central portion tapering to relatively wide end portions for longitudinal liquid pressure equalization; said elongated liquid outlet being disposed for receiving liquid from a final said chamber.

10. A nozzle according to claim 9 characterised by an adjustment means for adjusting the shape of a sheet of liquid driven from the nozzle, by a frame member for the nozzle, and in that the adjustment means comprises a plurality of spaced adjustment screws longitudinally spaced along said frame member and each threaded to said frame member for exerting a cantilever pressure through said frame member urging a portion of said first and second lips to close or open upon threaded adjustment.

11. A nozzle according to claim 9 or 10 characterised by a central-drag plate extending through a last said chamber to said outlet for reducing the central velocity of liquid passing from said outlet such that a liquid sheet driven from said outlet will maintain its integrity further from said outlet.

12. A distillation column for use in distilling characterised by a column, and a plurality of elongated nozzle bodies each disposed in the upper end of said column and being according to claim 9, 10 or 11 and in that in each said nozzle a said second slot connects second and third said chambers and has a plurality of uniform, evenly spaced vertical openings disposed longitudinally thereacrosss for longitudinal liquid pressure equalisation; and a said third slot connects third and fourth said chambers and has a relatively uniform width for longitudinal liquid pressure equalisation.

13. A column according to claim 12 characterised by a level control means disposed in said column to control the level of liquid in said column by vacuum means connected at the upper end of said column for producing a vacuum above said plurality of nozzles, and by microwave transmission means for transmitting microwaves into liquid to be distilled in said column.

14. A distillation column according to claim 12 or 13 together with a steam stripping column for steam stripping edible oil characterised by a column through which oil can be circulated for steam stripping; a domed body disposed at the lower end of said column for communicating steam to edible oil in which said body is submerged and having a chamber therein and an opening for communicating steam to said chamber, a plurality of relatively small tubes connected to said domed body and extending uniformly thereabout each having an inlet at said chamber, an outlet and a sufficient narrow passage therebetween such that the flow of steam through said passage is mainly dependent on the size of said passage as steam is distributed into edible oil liquid in said column.

15. A continuous process of deodorizing and refining an edible oil containing tocopherol and free fatty acids characterised by the steps of

(a) continuously supplying the edible oil to a first vacuum distiller and flowing said edible oil in driven sheets within said first distiller and distilling tocopherol from said edible oil; and

(b) continuously supplying, concurrent with step (a), edible oil from which topcopherol has been distilled in said first vacuum distiller to a second vacuum distiller and flowing said edible oil in driven sheets within said second distiller and distilling fatty acids from said edible oil.

16. A method according to claim 15 wherein the edible oil also contains air and water and/or lecithins and/or chlorophyll and/or hydrocarbons more volatile than tocopherol characterised in that the edible oil is continuously supplied concurrent with steps (a) and (b) to further vacuum distiller(s) or a bleaching device corresponding to said additional ingredients and said additional ingredients are vacuum distilled or removed from the edible oil therein and the edible oil from which said additional ingredients are removed is supplied to step (a).

17. A distillation column nozzle for use in driving a sheet of liquid in a distillation column, comprising:

an elongated nozzle member having a liquid inlet on an upper side thereof, an elongated liquid outlet on the lower side thererof, and pressure equalisation means therebetween for equalising liquid pressure longitudinally across said outlet; and

a central drag plate disposed in said nozzle member and extending from said pressure equalisation means to said elongated liquid outlet for reducing the central velocity of liquid passing from said outlet such that a liquid sheet driven from said outlet will maintain its integrity further from said liquid outlet.

18. A sparging nozzle for distributing gas bubbles in a liquid comprising:

a domed body having a chamber therein and an opening for communicating gas to said chamber;

a plurality of relatively small tubes connected to said domed body and extending uniformly thereabout each having an inlet at said chamber, an outlet and a sufficient narrow passage therebetween such that the flow of gas through said passage is mainly dependent on the size of said passage as gas is distributed as gas bubbled in a liquid.

19. A steam stripping column for steam stripping edible oil comprising:

a column through which oil can be circulated for steam stripping;

a domed body disposed at the lower end of said column for communicating steam to edible oil in which said body is submerged and having a chamber therein and an opening for communicating steam to said chamber;

a plurality of relatively small tubes connected to said domed body and extending uniformly thereabout each having an inlet at said chamber, an outlet and a sufficient narrow passage therebetween such that the flow of steam through said passage is mainly dependent on the size of said passage as steam is distributed into edible oil liquid in said column.

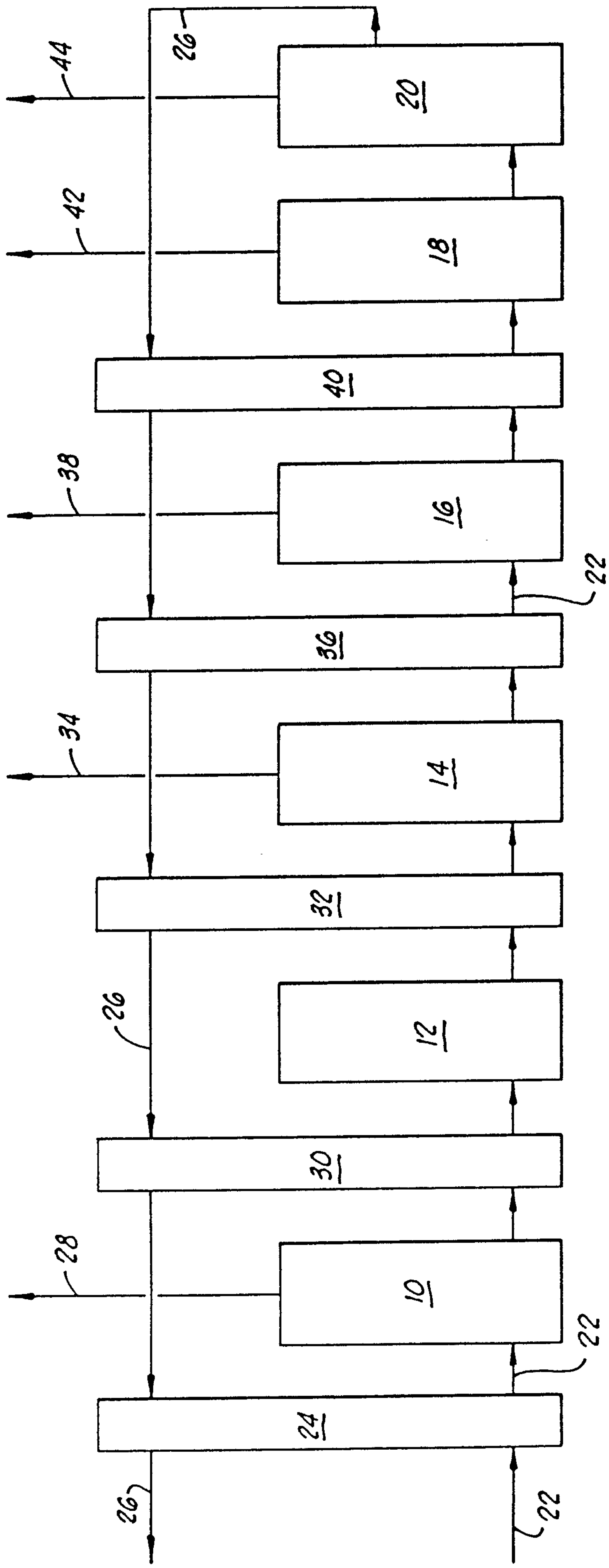
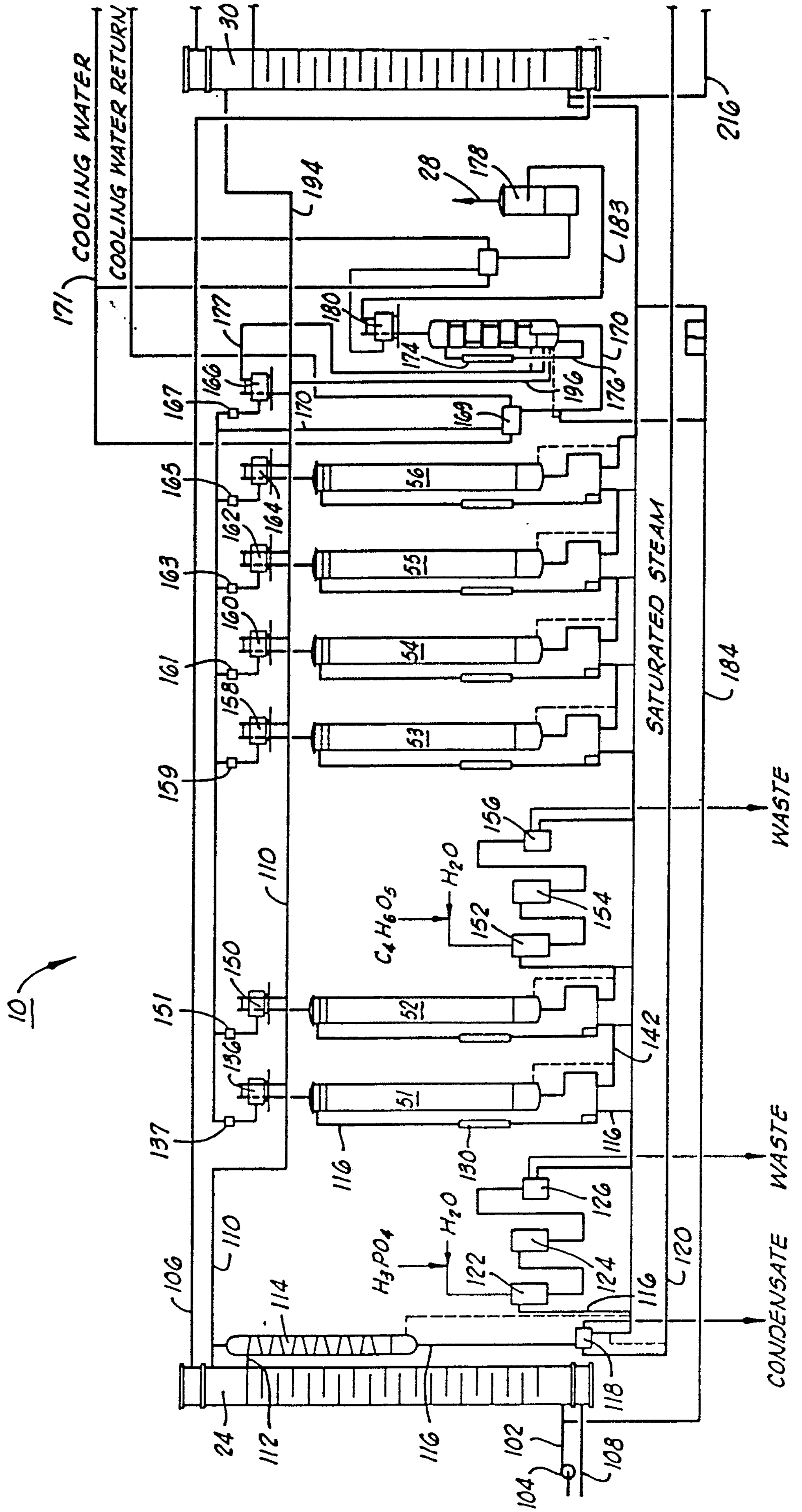


FIG. 1


COOLING WATER
COOLING WATER RETURN
SATURATED STEAM
WASTE
WASTE
CONDENSATE
H_3PO_4
H_2O
$C_4H_6O_5$
H_2O
10
24
28
30
51
52
53
54
55
56
102
104
106
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216

FIG. 2A

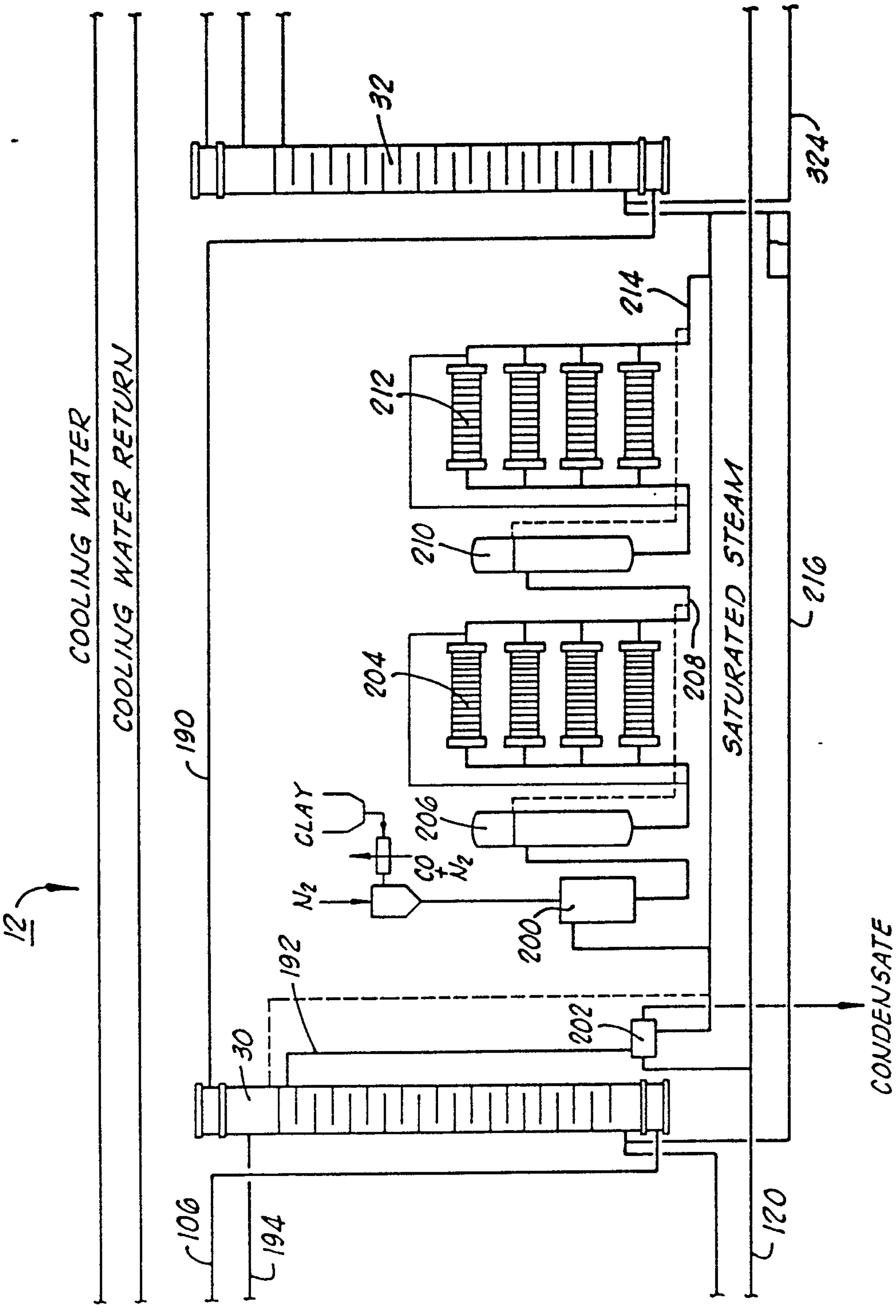

12
COOLING WATER
COOLING WATER RETURN
190
192
30
32
324
214
212
210
204
206
208
200
202
CLAY
CO + N2
N2
SATURATED STEAM
216
CONDENSATE
106
194
120

FIG. 2

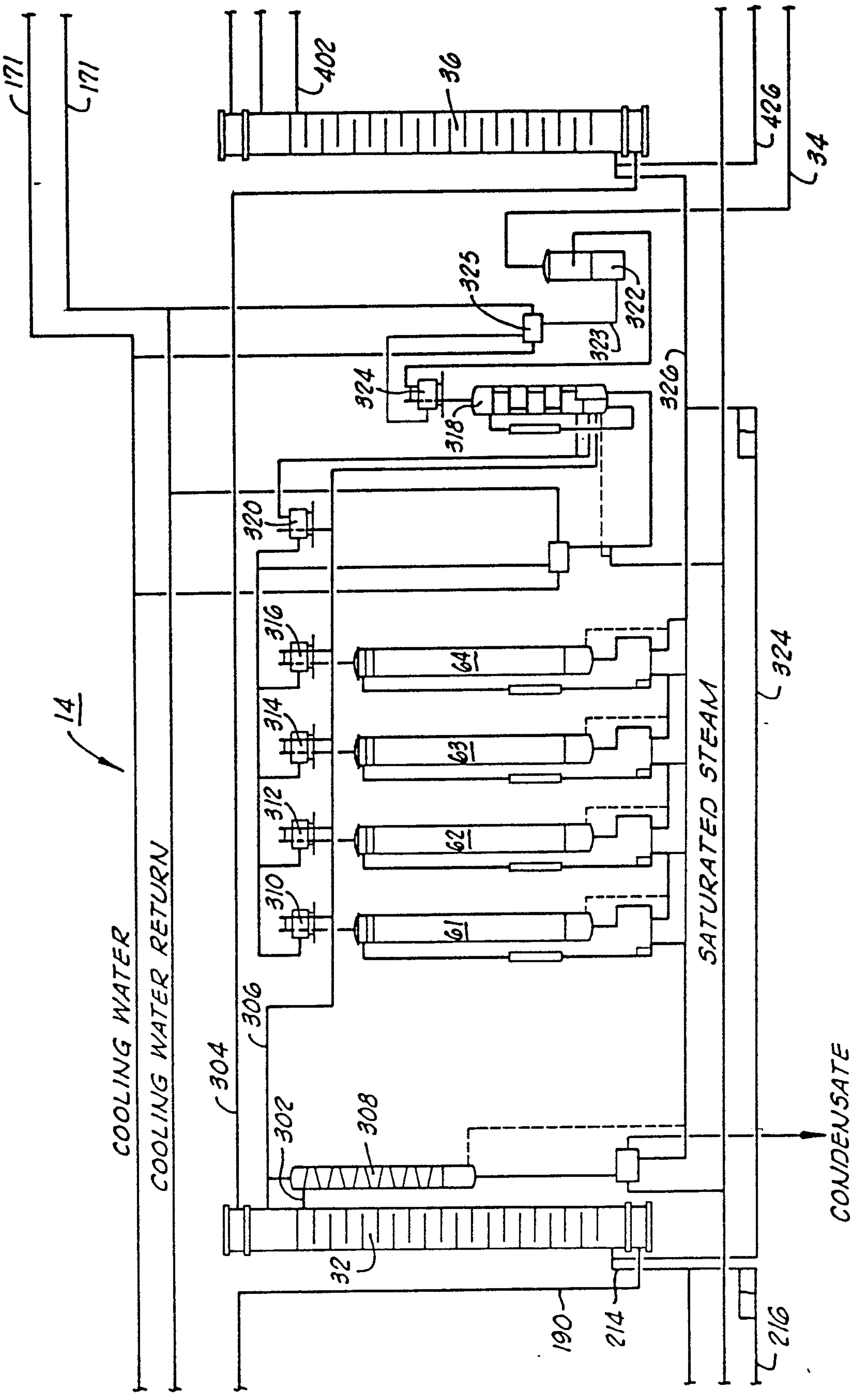
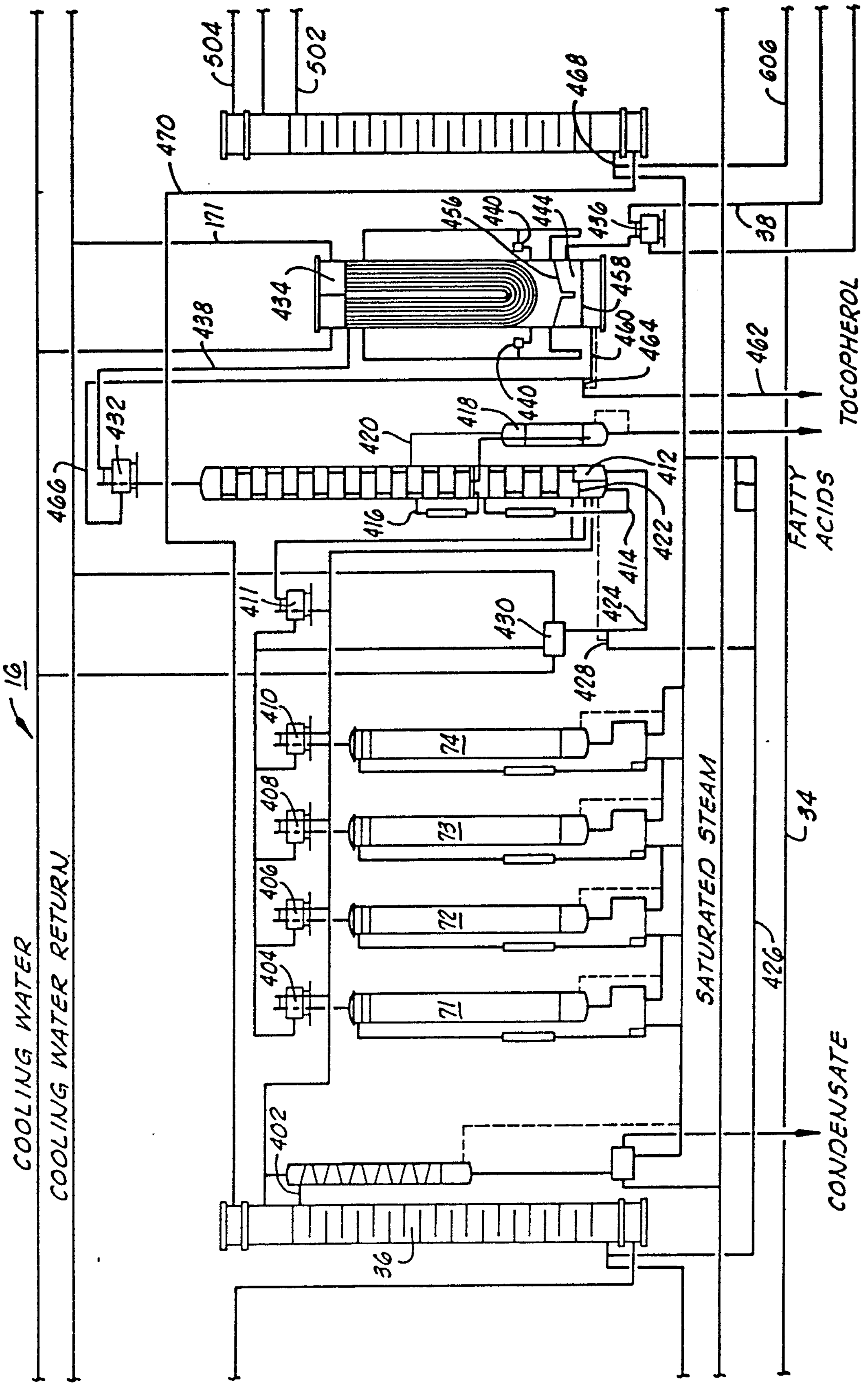

14
COOLING WATER
COOLING WATER RETURN
171
171
402
36
426
34
325
322
323
324
326
318
320
316
314
312
310
64
63
62
61
SATURATED STEAM
324
306
304
302
308
CONDENSATE
32
190
214
216

FIG. 2C



COOLING WATER
COOLING WATER RETURN
SATURATED STEAM
CONDENSATE
FATTY ACIDS
TOCOPHEROL
16
504
502
468
606
470
171
456
440
444
436
38
434
458
438
460
464
462
432
418
420
440
466
412
416
422
414
411
430
424
428
410
74
408
73
406
72
404
71
34
426
402
36

FIG. 2D

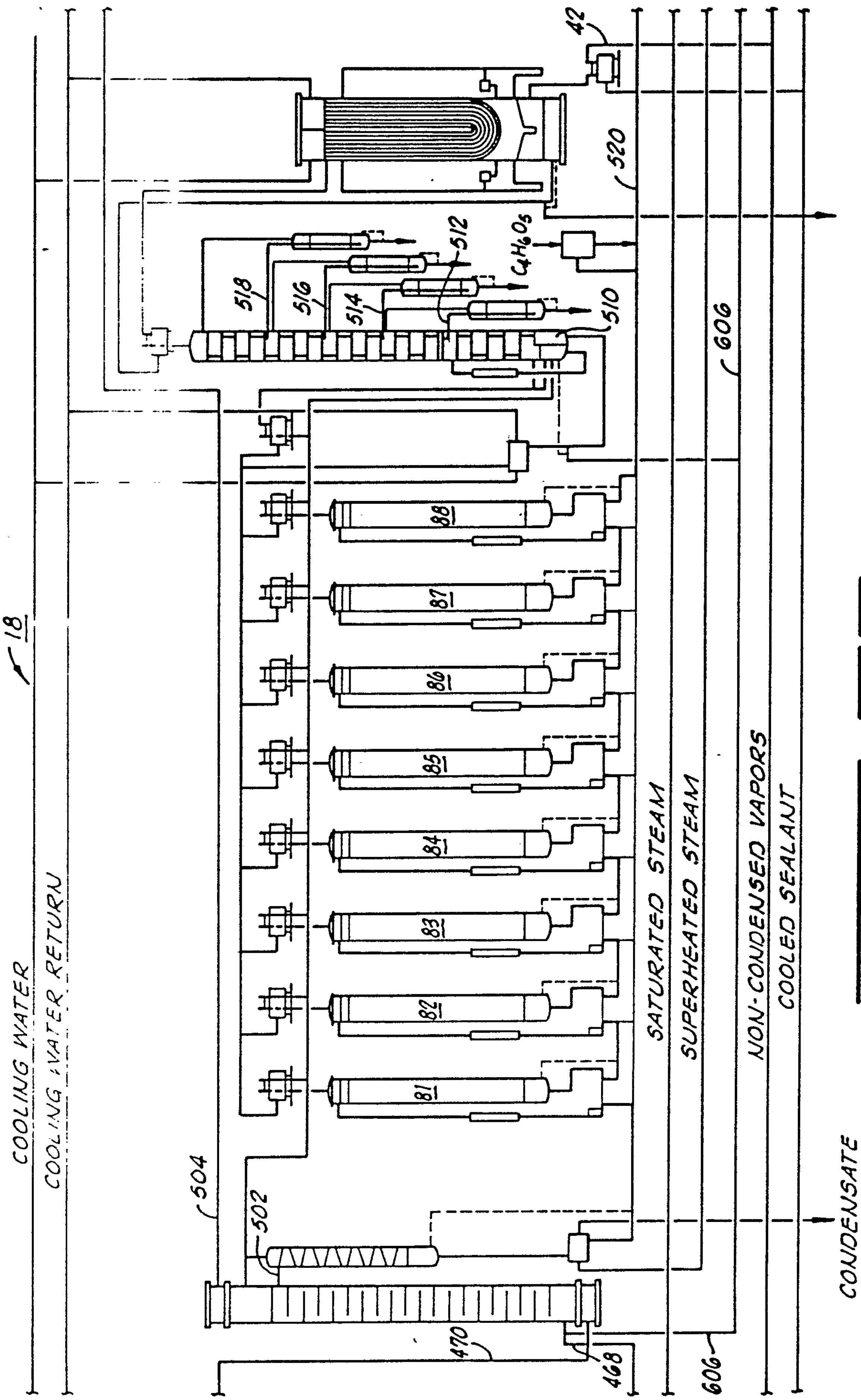

18
COOLING WATER
COOLING WATER RETURN
SATURATED STEAM
SUPERHEATED STEAM
NON-CONDENSED VAPORS
COOLED SEALANT
CONDENSATE
42
520
512
518
516
514
510
$C_4H_6O_5$
606
88
87
86
85
84
83
82
81
504
502
470
468
606

FIG. 2E

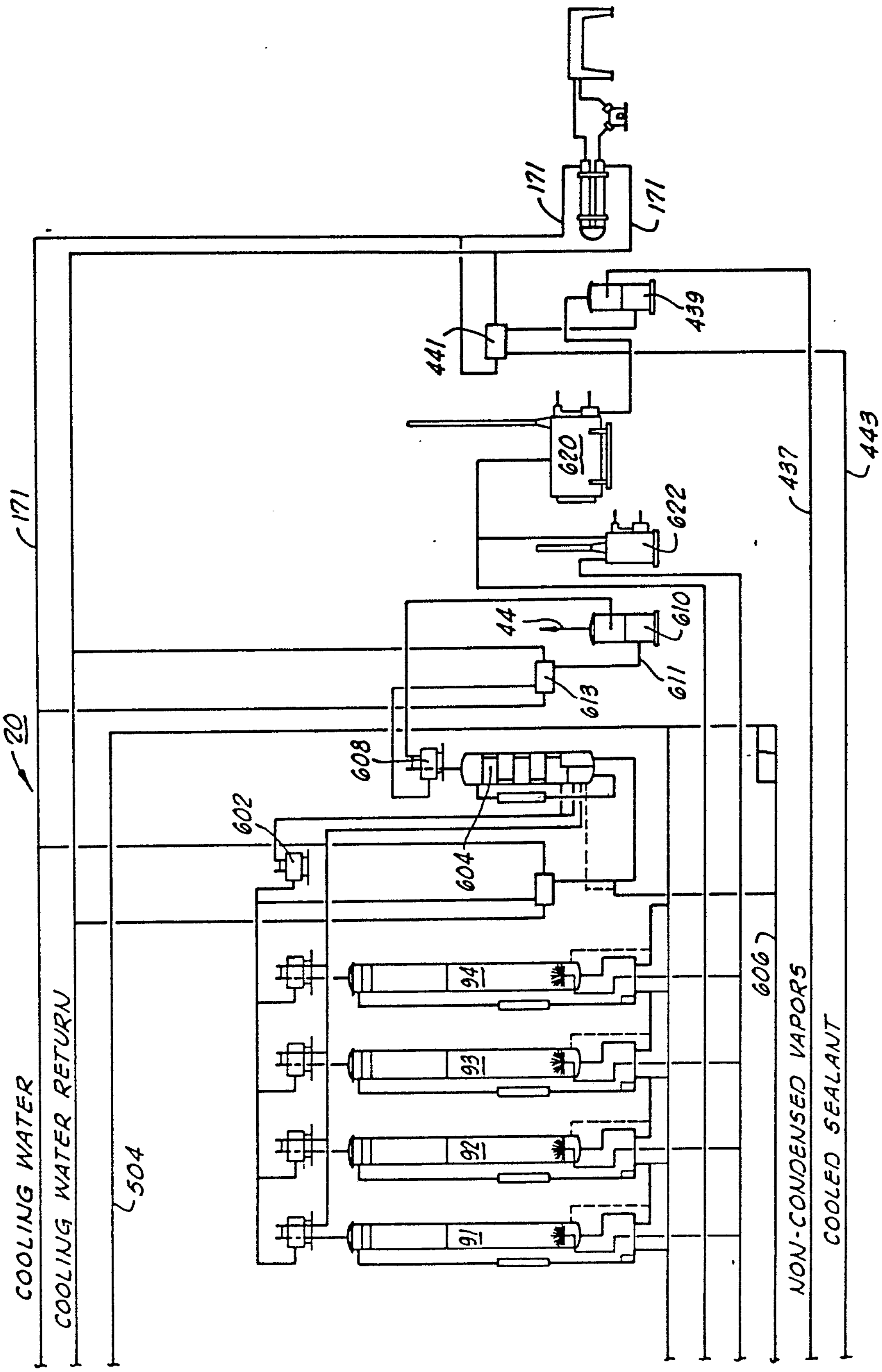

COOLING WATER
COOLING WATER RETURN
504
20
171
171
171
441
439
437
443
620
622
44
610
611
613
608
602
604
606
91
92
93
94
NON-CONDENSED VAPORS
COOLED SEALANT

FIG. 2F

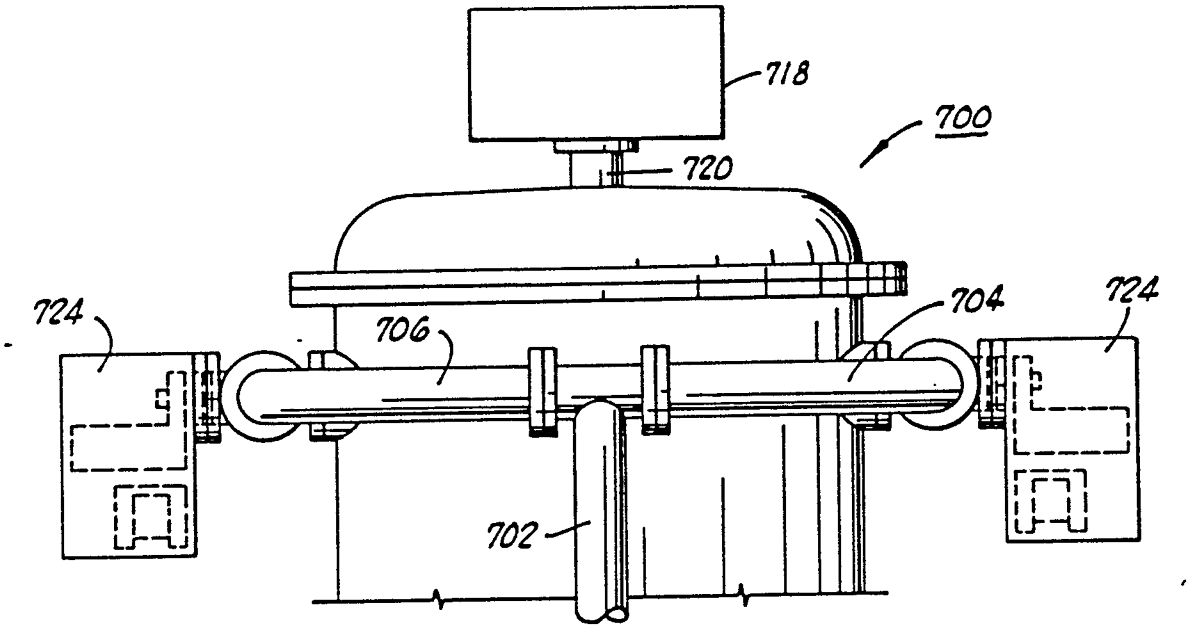

718
700
720
724
706
704
724
702

FIG. 3

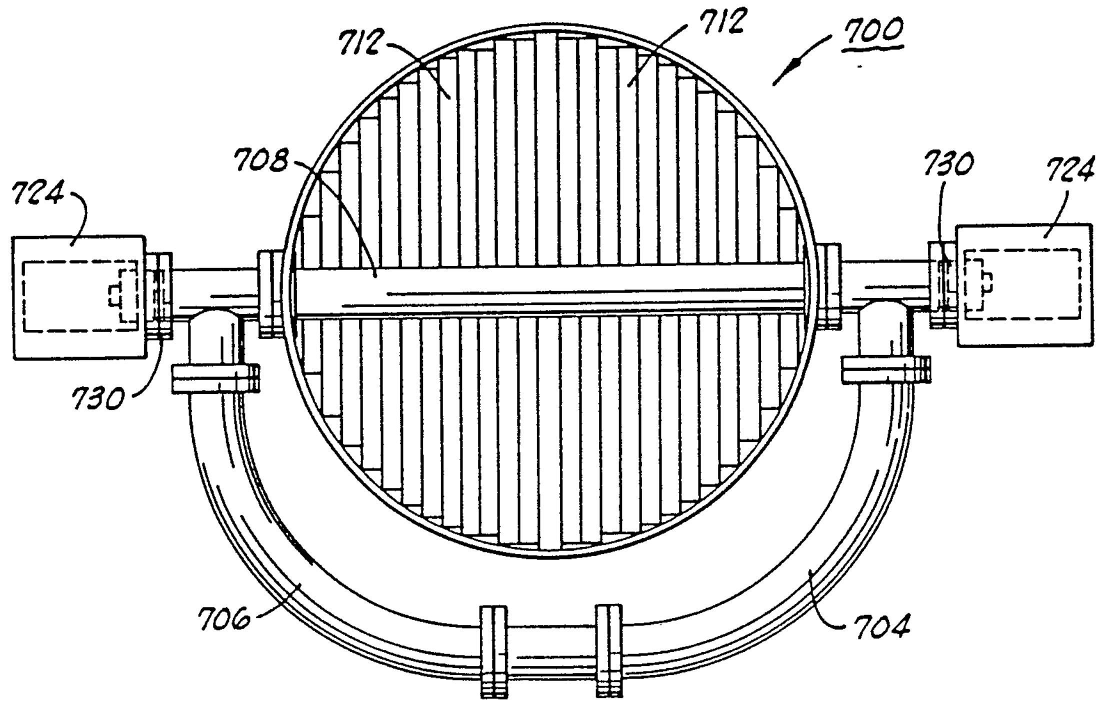

712
712
700
708
730
724
724
730
706
704

FIG. 4

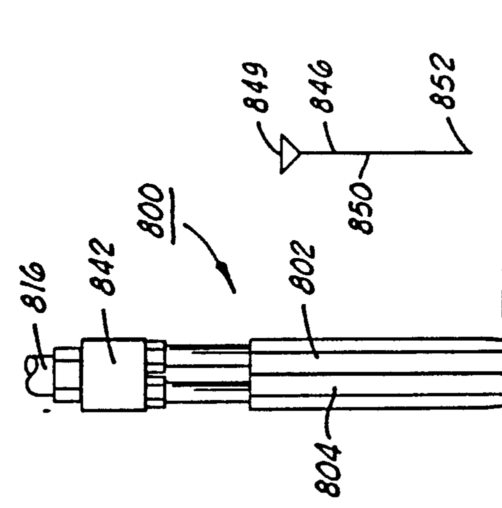


FIG. 10C

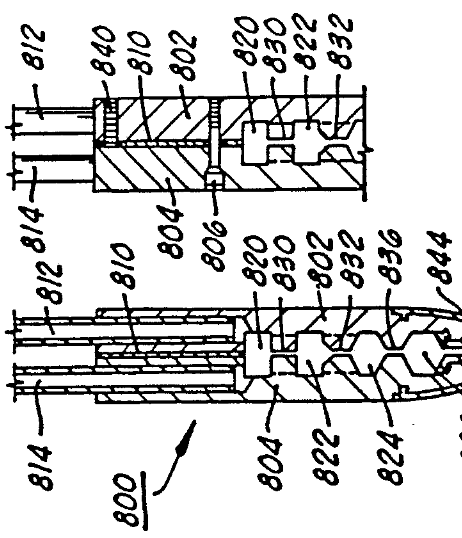


FIG. 10B

FIG. 10A

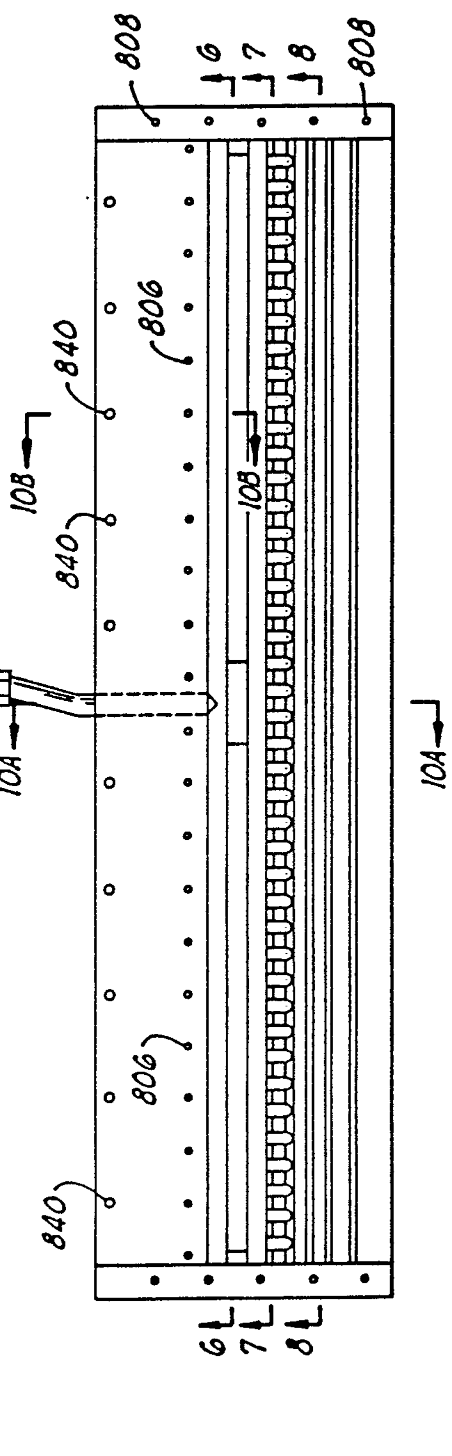


FIG. 9

FIG. 5

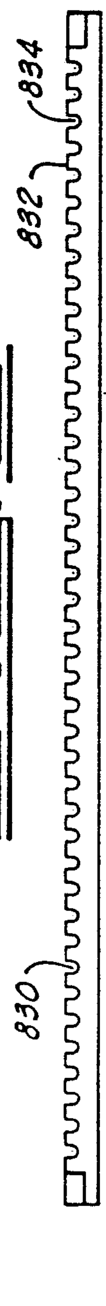


FIG. 6

FIG. 7

FIG. 8

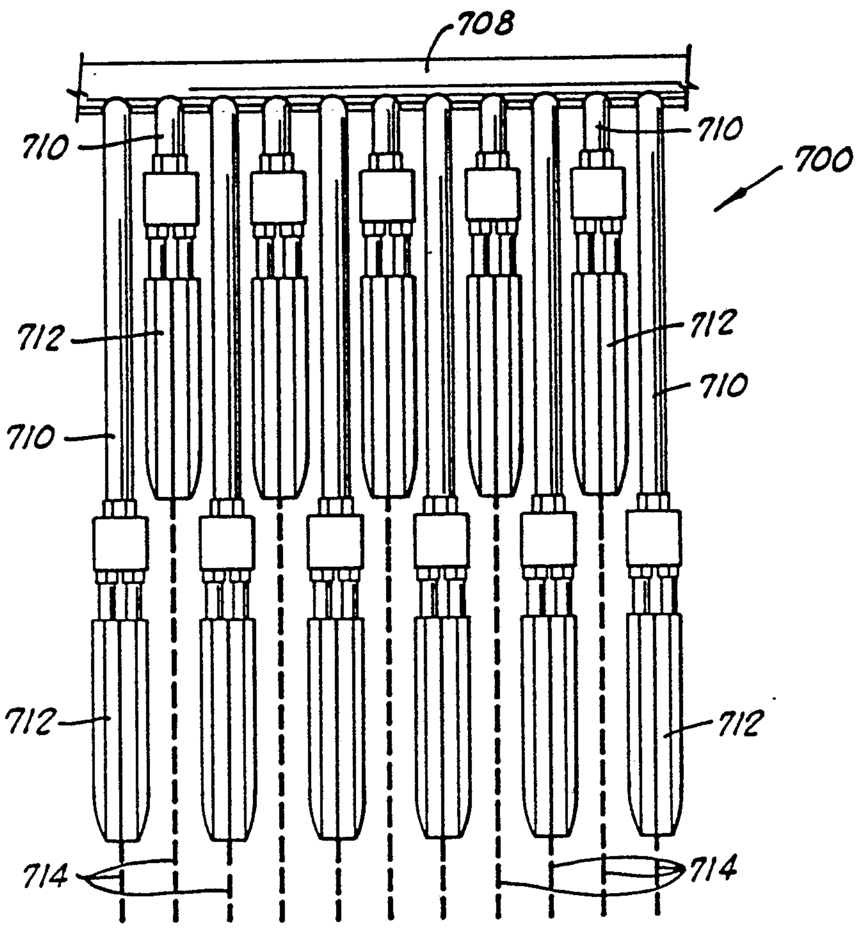

708
710
710
700
712
712
710
710
712
712
714
714

FIG. 11

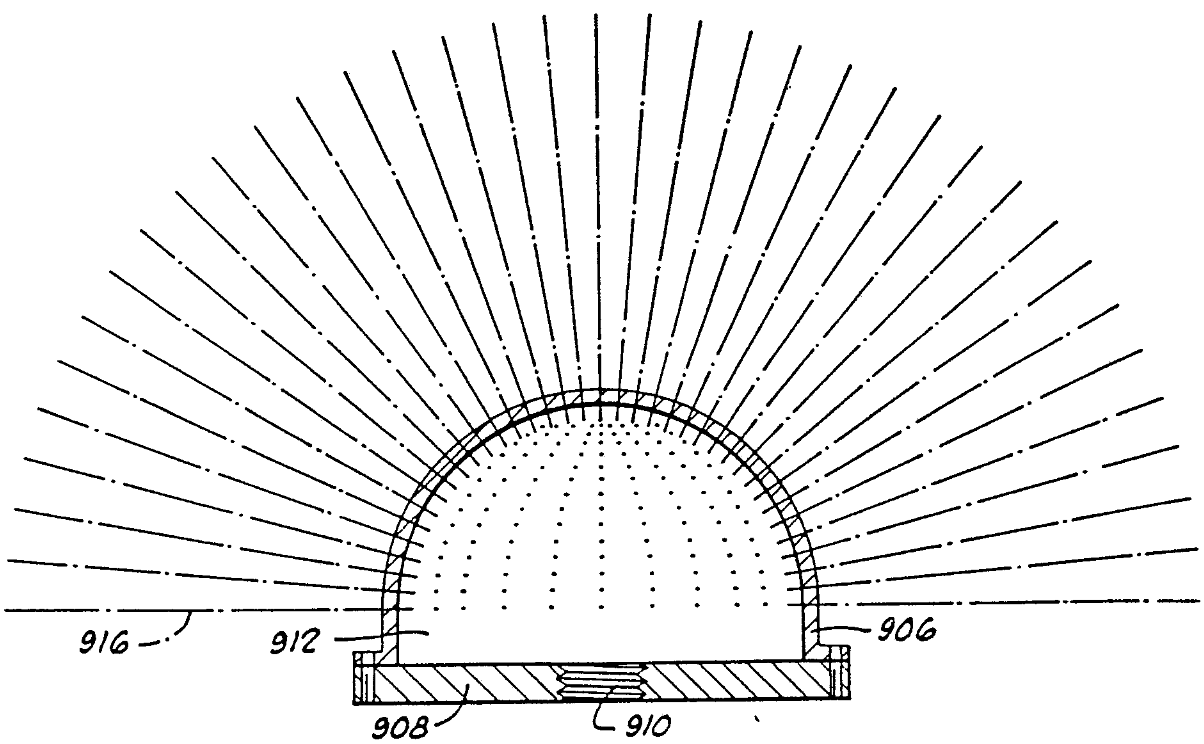

916
912
906
908
910

FIG. 13

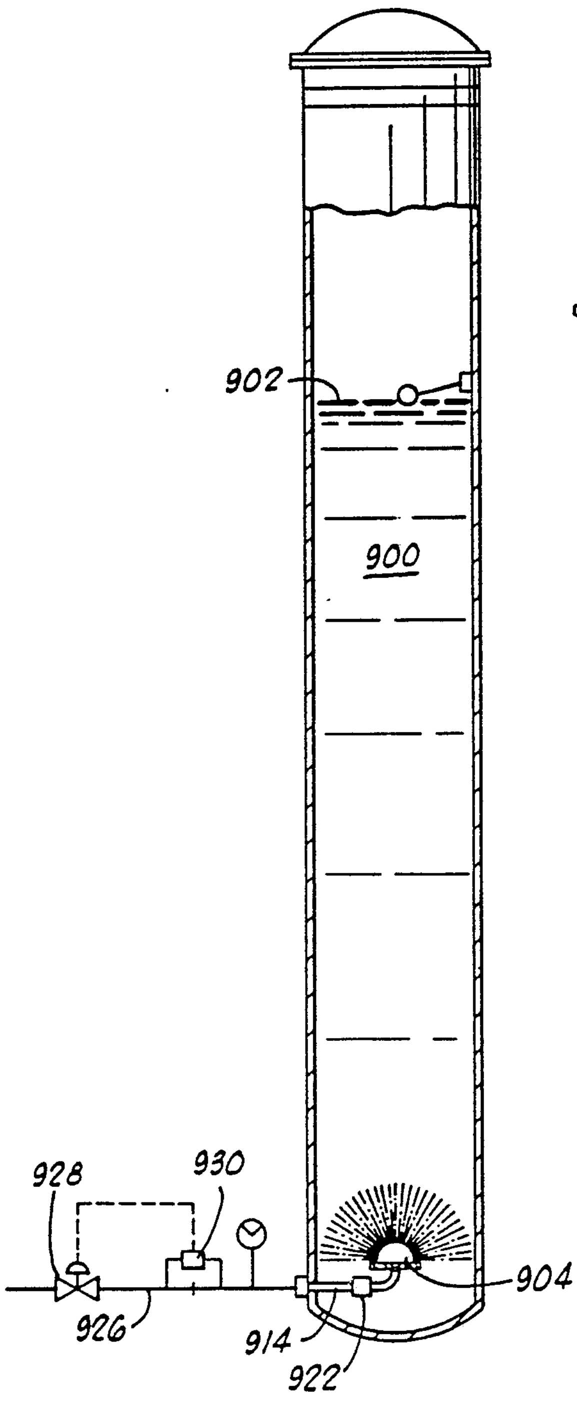


FIG. 12

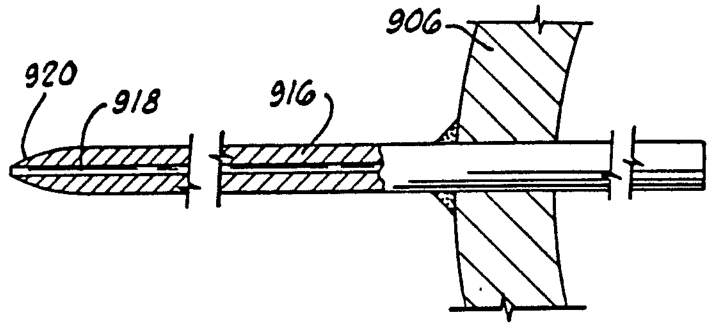


FIG. 14

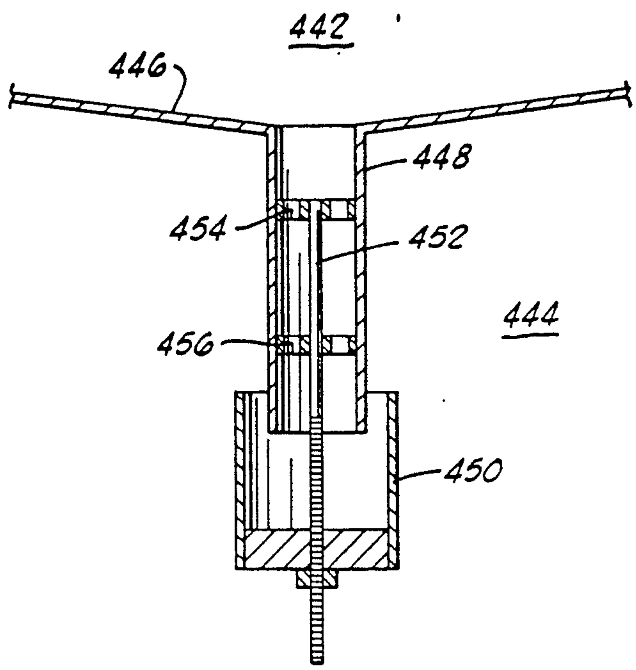
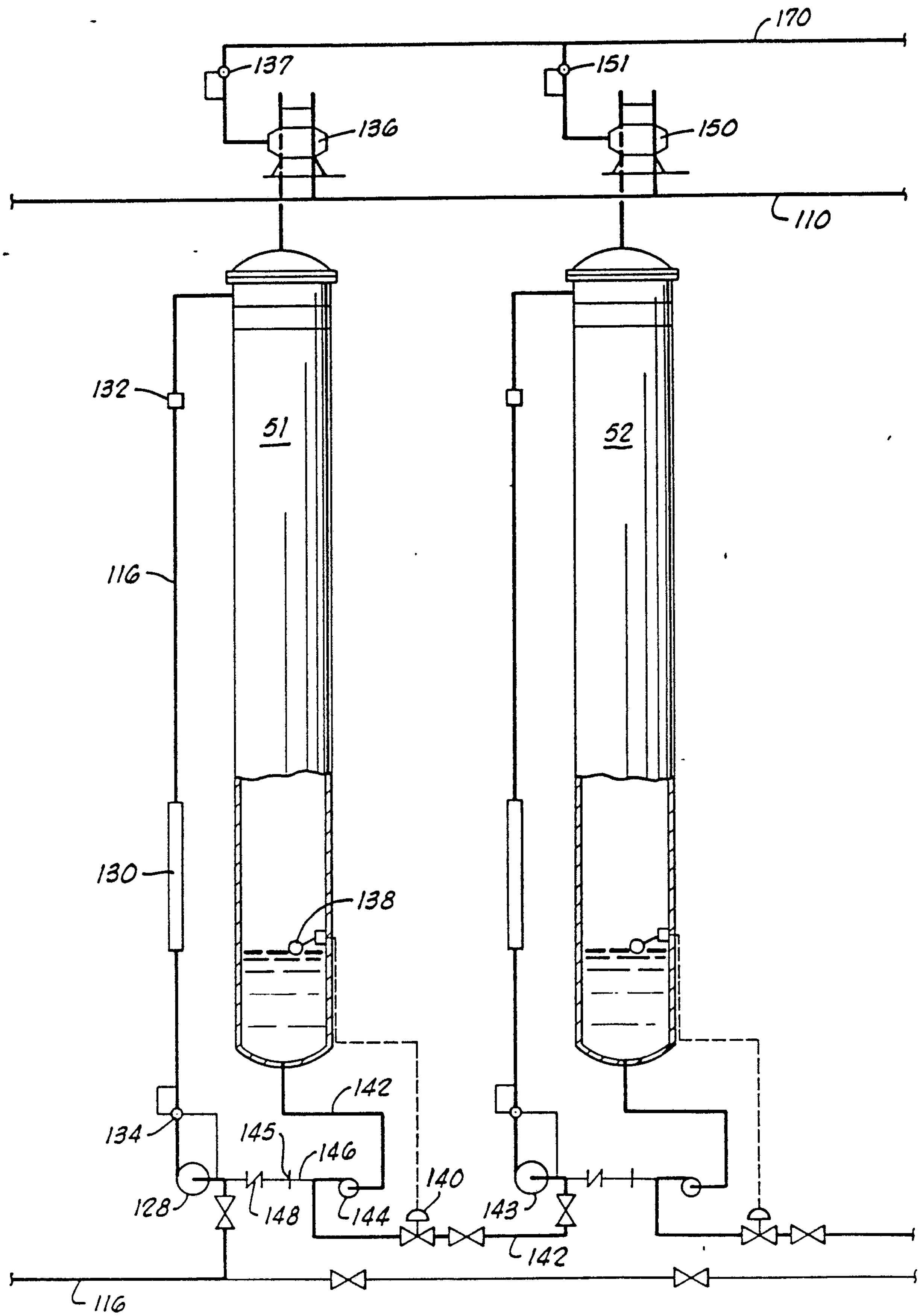


FIG. 15


170
137
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142
116

FIG. 16

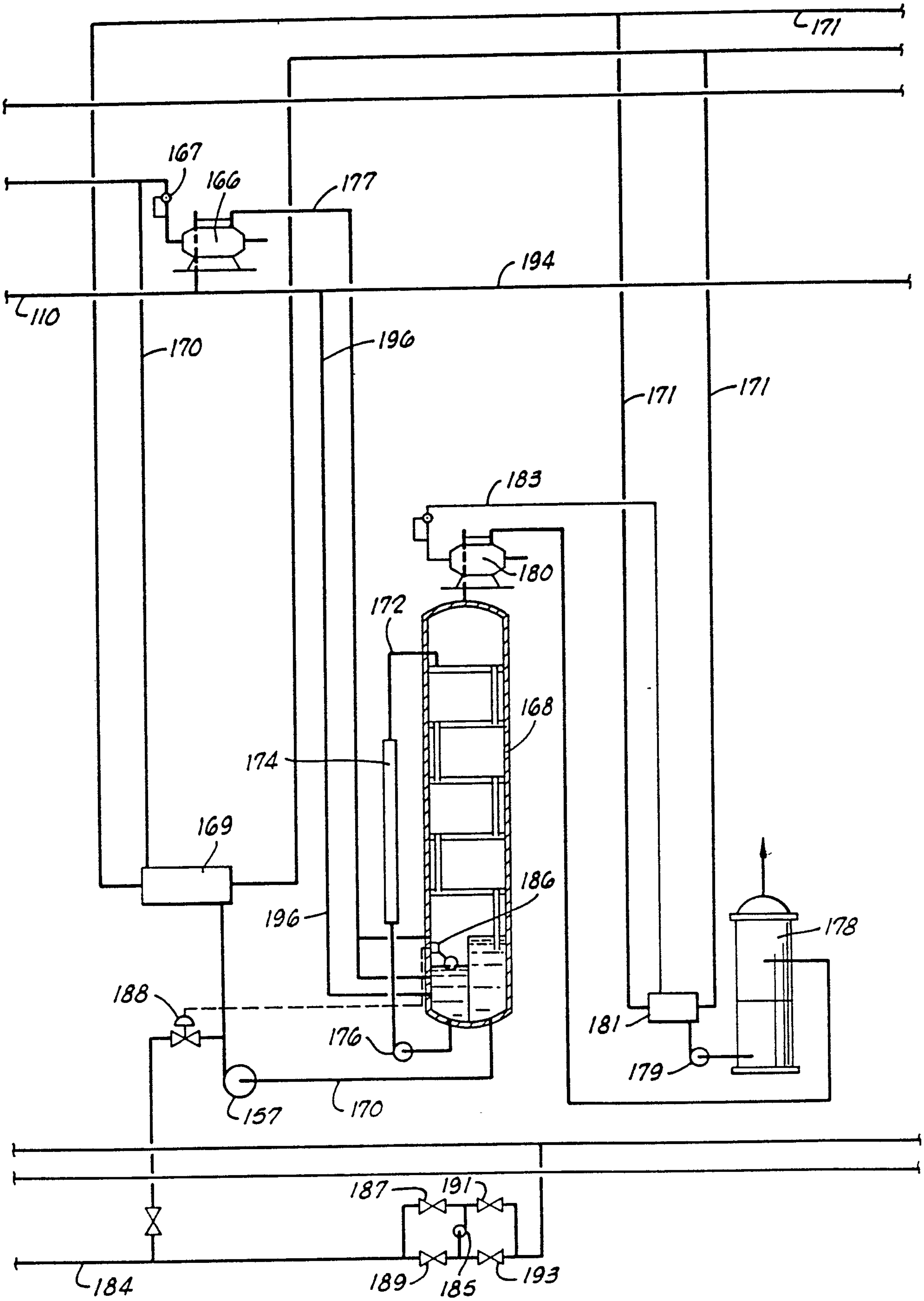
171
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FIG. 17

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 86 30 1567

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	EP-A-0 119 639 (SHELL INTERNATIONALE RESEARCH MIJ.) * Claims 1-3,7-11; figures 1,2,4; page 4, lines 13-24,28-35; page 5, lines 1-10; page 6, lines 16-36; page 7, lines 11-13 * ---	1,2,4, 9-13, 17	C 11 B 3/00 C 11 B 3/12 B 01 D 3/00 B 01 D 3/28
A	EP-A-0 101 888 (H. STAGE) * Claims 1,16,17; figures 1,3,4,6; example 1; page 16, lines 27-36; page 17; page 19, lines 35,36; page 20; page 21, lines 5-16 * ---	1-19	
A	US-A-4 089 880 (F.E. SULLIVAN) * Claims 1-4,7,8; figures; column 6, lines 46-68; columns 7-11; column 12, lines 1-31 * ---	5-8,15 ,16	TECHNICAL FIELDS SEARCHED (Int. Cl.4)
A	DE-B-1 934 959 (KETTLITZ-CHEMIE) * Claims 1,9,10; figures * -----	1,3	C 11 B B 01 D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	03-11-1986	PEETERS J.C.

CATEGORY OF CITED DOCUMENTS

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L : document cited for other reasons

& : member of the same patent family, corresponding document